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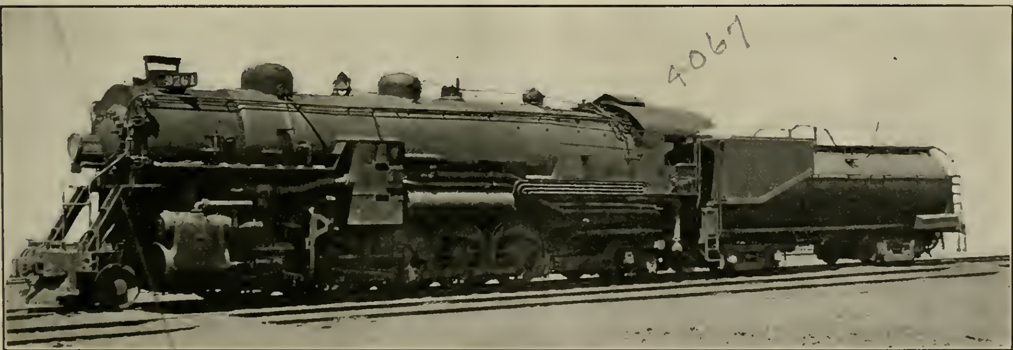
The Powerful Three-Cylinder Locomotive of the Southern Pacific Co.

Some Details of the Performance of a Heavy Non-Articulated 2-10-2 Locomotive

An announcement was made in the March 1925 isue of Railway and Locomotive Engineering of some 2-10-2 three-cylinder locomotives, then in course of construction for the Southern Pacific Company by the American Locomotive Company. In that article a chart was presented showing the increase in the hauling capacity of Southern Pacific locomotives for the past thirty years as expressed in drawbar pull in pounds on a 2.2 per cent grade. This showed that the increase at starting from the ten-wheeled saturated steam locomotive built in 1895 and weighing 249,370 lbs. to the 2-10-2 three-cylinder machine weighing 682,400, was from a drawbar pull of 18,000 lbs. to one of 71,500 lbs.; while, at a speed of 35 miles per hour, the increase was from 1,000 lbs. to 21,500 lbs. This article was followed in September, 1925, after the engines had been delivered, by a second article giving a brief general description of them.



Three-Cylinder 2-10-2 Type Locomotive of the Southern Pacific Company

The engines were built in order to meet the increasing demands of the present as well as to make an adequate provision for the future handling in a satisfactory manner of the growing passenger and freight traffic over the heavy grades in the Sierra Nevada and Siskiyou Mountains.

After much study and investigation, it was decided that a three-cylinder locomotive operating with a maximum cut-off of 70 per cent and carrying a boiler pressure of 225 pounds, would offer the greatest possibilities of producing increased power at high speeds and of improving at the same time, the fuel efficiency of the locomotive. As a result, a three-cylinder 2-10-2 type locomotive was designed. Since the Southern Pacific is the first railroad to have a locomotive with this wheel arrangement built for its service, the new type has been designated as the "Southern Pacific."

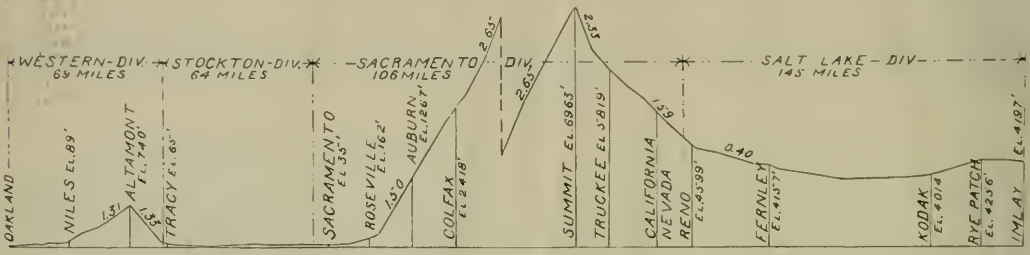
The general specifications for these locomotives were worked up under the supervision of George McCormick, general superintendent of motive power, and Frank E. Russell, mechanical engineer. The locomotives were built by the American Locomotive Company. The details were worked out jointly by the builders and Mr. Russell and represent the most recent developments of both the Southern Pacific Company and the American Locomotive Company.

Of the total of sixteen locomotives purchased by the Southern Pacific, six are in service on the Sierra Nevada Mountains between Roseville, California and Sparks, Nevada, and ten on the Siskiyou Mountains between Dunsmuir, California, and Ashland, Oregon. The character of the territory over which these locomotives operate is shown on the accompaning profiles.

On the line between Roseville and Sparks, maximum grades of 2.6 per cent occur going east, and of 2.3 per

cent going west. The consist of the through passenger trains over this district is from 10 to 13 cars, with a tonnage varying from 600 tons to 950 tons. Previously, when trains were of 11 cars or less, they were handled, single, by heavy 2-10-2 type locomotives having a tractive effort of 75,150 lbs. This locomotive was described in Railway and Locomotive Engineering for July 1921. When more than 11 cars were handled, it was necessary to give the 2-10-2 type locomotives a 2-8-2 type helper, or use two 2-8-2 type locomotives the tractive effort of the latter being 51,100 lbs. The time card calls for schedules for the San Francisco Overland Limited Trains, going East, as follows: from Roseville to Colfax, with a maximum grade of 1.5 per cent, 26.3 miles per hour; and

per cent cut-off is that the steam is used more expansively, thus reducing fuel consumption. A greater power output is also produced at any given cut-off, through the increase in boiler pressure above the normal. Furthermore, with the valve gear designed to give full port opening with a maximum cut-off of 70 per cent, the port opening is greater at any given cut-off than is the case when the initial cut-off is more than 70 per cent. This results in a wider port opening when the engine is hooked up, with a consequent increase in horsepower and hauling capacity at high speeds. At slow speeds, the low adhestion for the drivers of 3.75 is made possible by the use of the third cylinder, which produces a more uniform pulling torque. In any locomotive the adhesive weight must be great



Profile of Southern Pacific Railway From Oakland, Calif., to Imlay, Nev.

from Colfax to Summit with a maximum grade of 2.6 per cent, 18.7 miles per hour. It is a source of gratification to the railroad company that while the new Southern Pacific type locomotives were designed to handle a maximum of 12 cars on the San Francisco Overland Limited without help, they have successfully handled 13 cars, weighing 950 tons, on this train, and 14 cars on other trains having slower schedules. This eliminates the expense of using helpers on passenger trains over this territory.

To date on the Shasta Route, on account of heavy freight business, these locomotives have been used almost exclusively in freight service, with equally satisfactory results. Between Gerber and Dunsmuir, where helpers

enough to prevent slipping with the maximum tractive force developed through a complete revolution of the drivers. The increase in per cent of this maximum over the average is much smaller for a locomotive with three cylinders than for one with two cylinders. Hence, for a given weight on drivers, the three-cylinder locomotive can develop about 15 per cent more rated tractive effort than a two-cylinder design without slipping the wheels. The factor of adhesion of 3.75 for Southern Pacific type locomotives would be equivalent to about 4.25 in a two-cylinder type.

By increasing the weight on the drivers only 3.2 per cent the railroad has secured in the main cylinders of the Southern Pacific type locomotive an increased tractive

Profile of Southern Pacific Railway From Oakland to Ashland, Calif.

are not required, the average monthly performance shows that they have handled over 16 per cent more tonnage than the 2-10-2 type and at a fuel saving of 12 per cent per 1,000 ton miles.

The Southern Pacific type locomotives have a total weight of 442,000 lbs., of which 316,000 lbs. are on the drivers. The maximum tractive effort is 96,530 lbs. with the booster, and 84,200 lbs. without the booster, the ratio of adhesion for the drivers being 3.75. The maximum cut-off is 70 per cent, instead of 85 to 90 per cent, as is the usual practice. While the reduced cut-off alone lessens the tractive effort, the increase in boiler pressure to 225 lbs. offsets this. The advantage, then, of the 70

effort of 12.1 per cent over the heavy 2-10-2 type locomotive. Furthermore, upon comparing the drawbar pull curves for these two locomotives at 20 miles per hour on a 2.2 per cent grade, it is seen that the drawbar pull is 25 per cent greater for the Southern Pacific type. This is a marked increase in hauling capacity at high speeds on heavy grades.

The two diagrams show the drawbar pull of the 2-10-2 locomotive on 1.5 and 2.2 per cent grades as compared with the old T-1 class or 4-6-0 type, and the class F-5 or 2-10-2 type, the latter locomotive having been placed in service in 1924.

From these diagrams it will appear that, on a 1.5 per

cent grade the drawbar pull at starting for the three was as follows:

4- 6-0 = 19,000 lbs.
2-10-2 = 62,000 lbs.
2-10-2 = 76,000 lbs.

At a speed of 40 miles per hour these became:

4- 6-0 = 1,000 lbs.
2-10-2 = 16,000 lbs.
2-10-2 = 21,000 lbs.

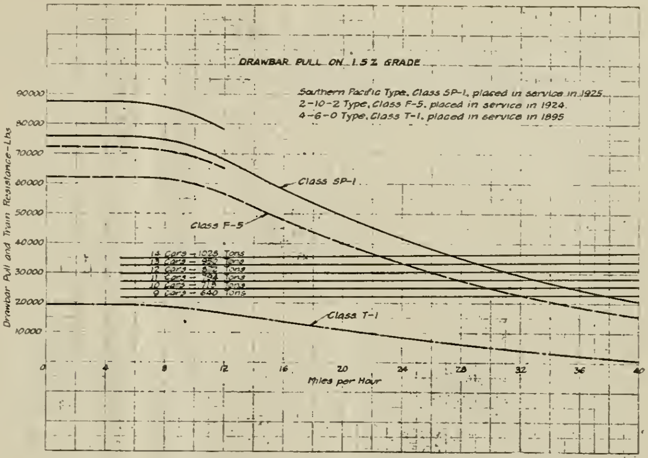
On a 2.2 per cent grade the drawbar pull drops and becomes, at starting

4- 6-0 = 17,500 lbs.
2-10-2 = 58,000 lbs.
2-10-2 = 71,500 lbs.

and at a speed of 40 miles an hour,

4- 6-0 = 0
2-10-2 = 11,500 lbs.
2-10-2 = 16,000 lbs.

By which the decided superiority of the 2-10-2 type over its predecessors is shown.



Comparison of Drawbar Pull on 1.5 per cent Grade of 2-10-2 Type and 4-6-0 Type Locomotives of the Southern Pacific Co.

Using Cole's ratios as a basis of comparison, these locomotives have a maximum cylinder horsepower of 3,798 and an evaporating capacity of 84.56 per cent. It is estimated, however, that the evaporating capacity is increased 10 per cent by the use of the feed water heater, and 6.76 per cent on account of the improved draft conditions due to the extra cylinder (based on 8 per cent of the evaporating capacity), making a total boiler capacity of 101.22 per cent. The actual performance of these locomotives shows that this boiler capacity is ample to keep the cylinders supplied at high speeds. These excelent steaming qualities are also attributed to some extent to the ample grate area, which is 90.36 square feet, and to the large firebox volume, which has a heating surface of 401 square feet.

4-6-0 Type Class T-1 Locomotive of the Southern Pacific Company

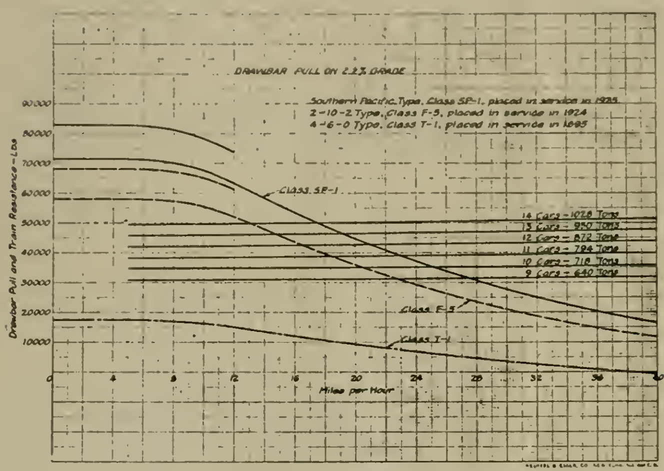
The boiler was so designed that it would have the largest proportions possible in order to provide sufficient steaming capacity while, at the same time, keeping within the limit of wheel load on the track. Further details of the boiler will be published in a future issue.

The steam distribution is controlled by double ported piston valves 11 inches in diameter having a maximum valve travel of 6 inches, a constant lead of 3/16", a steam lap of 1½" and an exhaust clearance of 1/16 inch. The outside piston valves are propelled by a direct Walschaert gear, the same as applied to two cylinder locomotives. The inside valve is driven by the Gresley valve gear, which gives the same travel to the middle valve as the outside valves, the timing of which is 120 degrees between the two outside valves. The valve gear is controlled by an Alco power reverse gear.

Because of the fact that the diameter of the cylinders is considerably reduced from what the diameter would be if the same engine had only two cylinders, the reciprocating parts are much lighter, resulting in less counterbalance in the wheels, and, consequently, in less dynamic augment. The inside main rod is connected to the axle of the second drivers instead of to that of the third or main wheels. In addition to reducing the stress on crank axle, this application of power to two instead of one driving axle very materially improves counterbalance conditions in that the main wheels are thus relieved of the necessity of carrying any extra balance for the inside rod. A general statement as to the manner in which these three-cylinder engines are balanced is as follows: As much as possible of the back half of the inside main rod is balanced in the crank axle. In the wheels are balanced all the revolving weights plus any deficient weight of the back half of the inside rod not balanced in the crank axle, together with 35 per cent of the reciprocating weights of the outside cylinders. None of the reciprocating weights of the inside cylinder is balanced. If sufficient balance cannot be put in the main wheels to cover the above, the deficient balance is carried in the other wheels in the same manner as on a two-cylinder engine.

With cranks set at 120 degrees instead of 90 degrees as on two-cylinder locomotives, the combined effect of two counterbalances on the rail and on the locomotive at one time is eliminated. All of this results in about one-third reduction of stresses set up in the roadbed and bridges due to counterbalance, thus enabling the railroad to take advantage of this reduction in dynamic augment by increasing static wheel loads. The following tabula-

tion shows the wheel and axle pressures on rail due to static loads and dynamic augment at 50 miles per hour for the Southern Pacific type locomotives as compared with the pressures for the 4-6-0 and 2-10-2 types. The interesting feature of the tabulation is that while the static load per axle for the Southern Pacific type is higher than



Comparison of Drawbar Pull of 2-10-2 and 4-6-0 Type Locomotives of the Southern Pacific Co., on 2.2 per cent Grade

that for the 2-10-2 type, the total pressure on rail per axle is lower.

A 6-feed Nathan mechanical locomotive lubricator is attached to the guide yoke on the right side of the engine, and operated by a rod connected direct to the reverse link. This device provides lubrication for the three cylinders and steam chests, making it necessary to apply only a three-feed hydrostatic lubricator in the cab—one feed each for the booster, the feed water heater, and the air compressors. The reduction in size of the hydrostatic lubricator in cab provides much needed space in which to locate all operating levers, gages, valves, etc., for the most convenient operation and still leave the cab comfortable.

The throttle valve is located in the smoke box, between the superheater header and the main steam cylinders. Connections are also made in the header to provide superheated steam for operating auxiliaries, such as the air compressors, feed water pump, head-light turbo-generator, oil atomizer and blower. In addition to supplying better steam to the auxiliaries, the location of throttle at front end has the advantage of giving the engineer better control in handling the locomotive and so enables him to prevent unnecessary slipping. The reduction in slipping of locomotive drivers should be productive of economy in both locomotive repairs and track maintenance.

Front end damper and deflecting plates are eliminated, which greatly facilitates making repairs in the smoke box.

The first pair of drivers is equipped with the American Locomotive Company's lateral motion device, and the spring rigging provides for the equalization of these drivers with the 4-wheel engine truck. This arrangement assists the locomotive in taking curves easily and helps to stabilize it whether on tangent track or on curves, practically eliminating the nosing action.

The cab is constructed with a sloping front end, which facilitates making repairs on the boiler as well as the inspection of staybolts at the extreme back end of the outside firebox sheets.

The locomotives are equipped with the Franklin Railway Supply Company's Type C-1 booster, which is attached to a Delta type trailing truck. The rear section of the frame is a Commonwealth Steel Company's cradle casting, the front end of which is so designed that the trailing truck can be dropped down without moving the truck back. This makes the booster and details more accessible for repairs. The booster engine is operated by superheated steam obtained from the steam chest of left cylinder. To insure against a possible engine failure due to to a broken steam pipe, the pipe is connected to a booster cut-out valve in the form of an angle valve, which is applied next to cylinder. Provision is made on the body for securing the same design of vacuum valve as the one applied to the steam chest of right cylinder.

The Westinghouse No. 6 ET brake equipment is applied, the air being supplied by two 8½ inch cross-compound compressors. The braking power is up to the maximum, since all the wheels of the locomotive are equipped with brakes. Clasp brakes are used on the tender truck wheels.

The flange lubricator is applied, which provides lubrication for the flanges of the front driving wheels. The oil reservoir is located on the left side of the smoke box, where the crude oil used is sufficiently heated to run through piping leading to the front driving wheel flanges, the flow being regulated by needle valves. Flange oilers are also applied to the trailing wheels.

The feed water is supplied by one Worthington combined feed pump and feed water heater of 7,200 gallons

WHEEL PRESSURE IN LBS. ON RAIL AT 50 MILES PER HOUR—EACH SIDE

	DRIVERS				
4-6-0 *Type*	1st	2nd	3rd	4th	5th
Static Wheel Load.......	18,675	18,675	18,675		
Dynamic Augment	8,820	1,230	8,755		
Total Wheel Pressure....	27,495	19,905	27,430		
2-10-2 *Type*					
Static Wheel Load.......	30,650	30,400	30,750	30,500	30,750
Dynamic Augment	9,510	8,835	2,610	7,705	9,060
Total Wheel Pressure....	40,160	39,235	33,360	38,205	39,810
Southern Pacific Type					
Static Wheel Load.......	31,750	31,800	31,450	31,500	31,500
Dynamic Augment	6,700	8,850	9,600	8,120	6,770
Total Wheel Pressure....	38,450	40,650	41,050	39,620	38,270

COMBINED WHEEL PRESSURE IN LBS. ON RAIL AT 50 MILES PER HOUR

	DRIVERS				
4-6-0 *Type*	1st	2nd	3rd	4th	5th
Static Load per Axle.....	37,350	37,350	37,350		
Comb. Dynamic Augment.	12,475	1,740	12,380		
Total Pressure per Axle..	49,825	39,090	49,730		
2-10-2 *Type*					
Static Load per Axle.....	61,300	60,800	61,500	61,000	61,500
Comb. Dynamic Augment.	13,450	12,495	3,690	10,895	12,815
Total Pressure per Axle..	74,750	73,295	65,190	71,895	74,315
Southern Pacific Type					
Static Load per Axle.....	63,500	63,600	62,900	63,000	63,000
Comb. Dynamic Augment.	6,700	8,850	9,600	8,120	6,770
Total Pressure per Axle..	70,200	72,450	72,500	71,120	69,770

capacity per hour, and by one Nathan non-lifting injector, both located on the left side, the latter being used only in cases of emergency and when the locomotive is not working.

The "Viloco" sander with eight delivery pipes is applied, six pipes being used for forward sanding, and two pipes for backward sanding. Two of the forward sanding pipes lead to the trailing wheels, on account of booster being applied to truck.

Special attention has been given to the arrangement of steps at the front end leading from front bumper to running boards. The convenience thus afforded makes the headlight, train number indicating lamp, throttle valve, etc., readily accessible for inspection and repair.

The tenders are cylindrical, having a capacity of 4,400 gallons of fuel oil and 12,000 gallons of water. The tank is carried on a Commonwealth cast steel one piece frame. The six-wheel trucks are also of the Commonwealth design, which is an equalized pedestal type, having cast steel frames and swing bolsters, and fitted with both helical and semi-elliptic springs, and will be illustrated in detail in a future issue. Side bearings are used on both front and rear trucks.

The tenders are equipped with four water tank manholes to facilitate spotting the locomotive when taking water.

There are a number of other interesting details entering into the construction of these locomotives which will be illustrated and described in a future issue.

It will be of interest to note the comparison of these locomotives with the standard passenger locomotives built for the Southern Pacific thirty years ago, and their 2-10-2 type locomotives built in the early part of 1924, which is shown in the accompanying table of principal dimensions, weights and proportions for the three types.

TYPE	4-6-0	2-10-2	Southern Pacific
Class	T-I	F-5	SP 1
Date built	1895	1924	1925
Cylinders, dia. and stroke	20"x26"	29½"x32"	One 25"x28" Two 25"x32"
Tractive effort with booster		86,100 lbs.	96,530 lbs.
Tractive effort without booster	25,260 lbs.	75,150 lbs.	84,200 lbs.
Valve Gear, Type	Stephenson	Walschaert	Walschaert
Valves	Slide	Piston 15" dia.	Piston 11" dia.
Maximum travel	6"	7"	6"
Lead in fullgear	1/32"	¼"	3/16"
Lap	1"	1-¼"	1-½"
Exhaust clearance	1/32"	⅛"	1/16"
Cut-off in per cent	85.5%	84.5%	70.0%
Weights in working order:			
On drivers	112,050 lbs.	306,100 lbs.	316,000 lbs.
On front truck	30,300 lbs.	31,200 lbs.	65,500 lbs.
On trailing truck		60,600 lbs.	60,500 lbs.
Total engine	142,350 lbs.	397,900 lbs.	442,000 lbs.
Tender	107,020 lbs.	242,300 lbs.	246,200 lbs.
Engine and tender	249,370 lbs.	640,200 lbs.	688,200 lbs.
Wheel Base:			
Driving	12'-2"	22'-10"	22'-10"
Rigid	12'-2"	16'-9"	16'-9"
Total engine	22'-8"	42'-4"	45'-3"
Total engine and tender	47'-8-¾"	84'-1-¼"	87'-2-¼"
Wheels, diameter, outside tires	T-1	F-5	SP 1
Driving (tires 3¼" thick)	63-½"	63-½"	63-½"
Front truck	30"	33"	30"
Trailing truck (tires 3¾" thick)		45½"	45½"
Journals, diameter and length:			
Driving, main	7-½"x12"	13"x22"	11-½"x13"
Driving, front	7-½"x12"	11"x20"	11"x13"
Driving, intermediate, front		11"x13"	11-½"x13"

TYPE	4-6-0	2-10-2	Southern Pacific
Driving, others	7½"x12"	11"x13"	11"x13"
Front truck	5½"x10"	6"x12"	7"x12"
Trailing truck		9"x14"	9"x14"
Boiler:			
Type	Wagon Top	Straight Top	Straight Top
Steam pressure	180 lbs.	200 lbs.	225 lbs.
Fuel	Coal	Oil	Oil
Diameter, first ring—outside	60-⅛"	90"	90-⅛"
Firebox, length and width	96"x42-⅛"	132"x90"	127¼"x102¼"
Combustion Chamber, length		64"	74"
Tubes, number and diameter	268-2"	261-2¼"	261-2¼"
Flues, number and diameter		50-5½"	50-5½"
Tubes and flues, length	12'-5½"	21'-0"	23'-6"
Grate area	28 sq. ft.	82.5 sq. ft.	90.36 sq. ft.
Heating surfaces:			
Tubes	1737 sq. ft.	3216 sq. ft.	3600 sq. ft.
Flues		1506 sq. ft.	1686 sq. ft.
Firebox	147 sq. ft.	378 sq. ft.	401 sq. ft.
Total evaporative	1884 sq. ft.	5100 sq. ft.	5687 sq. ft.
Superheating		1230 sq. ft.	1500 sq. ft.
Comb. evaporative and superheating	1884 sq. ft.	6330 sq. ft.	7187 sq. ft.
General Data:			
Cylinder horse power	1199 HP	3136 HP	3798 HP
Boiler horse power	1005 HP	3368 HP	3844 HP
Steam required per hour	32,373 lbs.	65,229 lbs.	78,998 lbs.
Evaporating capacity of boiler per hour	27,136 lbs.	63,570 lbs.	66,720 lbs.
Equivalent evaporating capacity of feed water heater per hour		7,900 lbs.	7,900 lbs.
Increased evaporating capacity due to draft a/c 3 cylinders			5,340 lbs.
Total evaporating capacity	27,136 lbs.	71,470 lbs.	79,960 lbs.
Evaporating capacity of boiler in per cent	83.8%	97.4%	84.46%
Evaporating capacity of feed water heater in per cent		10.00%	10.00%
Increased evaporating capacity due to draft a/c 3 cylinders, in per cent (based on 8% of evaporating capacity of boiler)			6.76%
Total evaporating capacity in per cent	83.8%	107.4%	101.22%
Ratios:			
Tractive effort plus combined heating surface	13.4	11.87	11.72
Tractive effort x diameter drivers divided by combined heating surface	844.68	747.93	738.08
Firebox heating surface, grate area	5.25	4.58	4.44
Firebox heating surface, per cent of evaporating heating surface	7.8	7.41	7.05
Superheating surface, per cent of evaporating heating surface		24.11	26.38
Tube length, sectional area of tube outside	47.59	63.37	70.92
Combined heating surface, grate area	67.28	76.72	79.54
Tender:			
Type	Rectangular	Vanderbilt	Vanderbilt
Tank	Rectangular	Cylindrical	Cylindrical
Water capacity	4,500 gal.	12,000 gal.	12,000 gal.
Fuel capacity	10 tons	4,000 gal. oil	4,400 gal.
Trucks	4-wheel	6-wheel	6-wheel
Truck wheels	33" steel	33" steel	33" steel
Truck journals	5"x9"	6"x11"	6"x11"

American Railroads in 1925—and in 1926

By Robert S. Binkerd, Vice Chairman, Eastern Presidents' Conference

The high hopes entertained for the year 1925 have been substantially realized. The improvement in the prices of farm products has tended to restore the farmer to his normal place in our economic life and has increased the demand for consumers' goods. The fundamental business activities of the country have been conducted with intelligent moderation. The bulk of the country's business has continued on a hand-to-mouth basis, avoiding excessive stocks of materials and goods, and reducing the cost of distribution to the consumer. Money and credit have remained relatively cheap, enabling the financing of practically all worthy projects for capital expenditure.

These sound general conditions have produced for the railroads a slightly larger traffic than they have ever heretofore carried. This traffic has been loaded and transported promptly and efficiently at a net return per ton-mile slightly lower than in 1924.

Yet this traffic has been made to produce the largest aggregate net operating income which the railroads have yet received and a substantially improved—though still inadequate—rate of return. In harmony with these facts, the average price of railroad securities is now higher than it was at the close of 1924 and an increasing interest and confidence in railroad investment appears to be in the making.

Freight Service

Figures for the month of December are not yet available, but it is expected that car loadings for the year 1925 will amount to nearly 51 million cars. This will be almost 2½ million cars in excess of the loadings of 1924 and nearly 6 million cars in excess of the loadings of 1920. Measured in ton-miles the transportation performances of 1925 will exceed any previous year, with the possible exception of 1923.

The traffic of 1925, like that of the preceding year, has been more difficult to handle. The largest increases have been in merchandise, miscellaneous and less-than-carload freight. These reflect the increased ability of the public to buy consumers' goods. The character of this increased traffic, however, tends to reduce the average number of tons carried in a car, and makes it impossible for the average load per car to equal that of other years in which higher proportions of bulk commodities are transported.

Notwithstanding the difficulties presented by the traffic of 1925, the railroads established eight important new high records:

In the total number of cars loaded in a single week;

In carrying peak loadings with a surplus of cars in reserve;

In the number of cars loaded with merchandise and less-than-carload freight in a single week;

In the number of cars loaded with miscellaneous freight in a single week;

In the number of ton-miles of transportation produced in a single month;

In the average movement of freight cars per day;

In the total number of cars moved in a single day;

In the average load per freight train during a single month.

Passenger Service

The long-distance passenger service of the railroads has been substantially increased and improved. In addition, there is now a definite trend toward acquiring desirable bus services and operating them as integral parts of the total service offered by railroads.

Passenger traffic was marked by a further decline, which seems mainly located in the field of short haul travel. The year was marked by the granting of more excursion rates than at any time since before the war, as a result of which the average revenue per passenger mile during the summer months was only about 2¾c., as against an average of approximately 3c. in the summer of 1921. The efforts to increase commutation rates have continued, for the simple reason that since commuters now constitute a larger proportion of passenger travel than ever before, any inadequacy in commutation rates has a much more serious effect upon the revenues derived from passenger service.

Facilities

The rehabilitation of the supply of cars and locomotives has been continued, but at a somewhat lower rate. It is the obvious intention of the railroads to have motive power and cars equal to any reasonable demand. But it is also their intention to exercise prudent economy in the making of additional capital investment. Having raised their efficiency to a point where each car and locomotive produces more transportation than it used to, the requirements for new purchases can no longer be based upon pre-war experience. Over any series of future years it is not likely that new cars and locomotives will be purchased in the numbers considered normal in years gone by.

The healthy tendency noted in 1924—toward an increase in the amount of capital expenditures devoted to additions and betterments to fixed property—has continued.

For the first time since 1916 construction of new line exceeded abandonment. More new construction than abandonment will apparently characterize 1926 also. For, during its current year, which ended October 31, 1925, the Interstate Commerce Commission granted 46 certificates for the construction of approximately 909 miles of new railroad, as against 46 certificates authorizing the abandonment of approximately 652 miles.

Rates

The rate situation has been marked by two important occurrences—the application of the western roads for a general 5 per cent increase; and the preparation for a general inquiry into the rate structure of the country, pursuant to the terms of the Hoch-Smith Resolution.

The great bulk of farm discontent after the war arose west of the Mississippi River. The inadequacy of the prices of farm products was mistakenly attributed to freight rates. Honest and sincere farm leaders fell into the economic fallacy of asserting that the farmer "pays the freight" both ways; although in the end the consumer of farm products, like the consumer of other commodities, is the ultimate payer of the cost of transportation.

The rates on agricultural commodities west of the Mississippi River are only about 27 per cent higher now than they were in 1911! Therefore, despite the efficient and economical operation in which the western carriers have vied with those of the east and south, it has been impossible for them to bridge the great gap between the increase in their elements of expense, and the slight increase in what they can charge for the service rendered.

The product of their rate structure is approximately 16

per cent below the levels of a fair return contemplated by the Transportation Act; so that from any point of view their modest request for a 5 per cent increase in rates would appear to be more than justified.

The Hoch-Smith Resolution declares agriculture to be "the basic industry in the country." It is based on the assumption that agricultural products pay too high a rate as compared with their value and that perhaps manufactured articles pay rates too low as compared with their value. The resolution is a direction to the Interstate Commerce Commission to ascertain whether or not this be true; and if true, to make readjustments accordingly.

The Interstate Commerce Commission took a number of steps during the year to conserve the revenue of the railroads. It refused the application for the abolition of the Pullman surcharge; it reversed its position on selling interchangeable mileage books at a 20 per cent reduction under the standard fare; and it reported adversely on demands for reduced rates on anthracite, on California citrus fruit, and on various other matters.

Earnings

The net operating income for the year we estimate at about 1 billion 120 million dollars, as against approximately 987 million dollars for 1924. This will mean a return of slightly more than 5 per cent on the property investment account. The increase in earnings in 1925 is practically the first financial reward for the improvements effected in railroad operation since the war.

Thanks to the progress made in increasing their efficiency and in getting a gradually increasing grip on their expenditures, the railroads are now in a position to turn modest increases in the volume of business into considerably larger improvement in net operating income.

The remorseless growth of railroad taxes still remains the most stubborn element in the cost of producing transportation. For 1925 we estimate them at 355 million dollars, or practically a million dollars a day. Thus, for the fourth year out of the past five, the amount paid in taxes will probably considerably exceed the amount which the railroads can prudently pay out in dividends.

Public and Labor Relations

Relations between the public and the railroads today are better than they have been for many years. One of the noteworthy events of the year was the report on public relations submitted to the annual convention of the National Association of Railroad and Utility Commissioners. This report took the position that the greatest credit to regulating authorities comes, not from the exercise of their power, but from the absence of any necessity for such exercise. This report constituted not only the first official recognition of the value of public relations work, but was in itself one of the most important evidences of the growth of constructive thought among officials engaged in the task of regulation.

During the year two additional Shippers Regional Advisory Boards were formed, one on the Pacific Coast and the other in New England. There are now twelve of these boards in existence covering practically the entire country. Intelligent cooperation between shippers and railroads continued on a nation-wide scale.

Relations between the employees of the railroads and their managements also continued to improve. Working for a railroad is getting to be one of the best stabilized employments in the country. During the past two years the fluctuations between the high point and low point of railroad employment have been considerably less than 100,000 men. This fluctuation is almost entirely accounted for by the necessity of contracting maintenance work during the winter months and of expanding it during the balance of the year.

1926 Forecast

For the first half of 1926 economic conditions seem to warrant belief in a continued broad production and distribution in most lines, with railway traffic probably at least upon a parity with the traffic of 1925. It is difficult to see beyond the middle of the year because of the importance which crops will have, not alone in traffic offered for transportation, but in replenishing and continuing the purchasing power of our great farming population. Should our 1926 crops be reasonably large in amount and fairly adequate in price, then the year 1926 may slightly surpass 1925 in the volume of traffic handled. The railroads will add to good times by perhaps larger purchases of cars and locomotives than in 1925 and by a continuance of important work on their track and structures. It would seem that new capital expenditures by the roads during the year will probably at least equal the 750 million dollars of this year.

The attitude of public opinion toward the improved earning power of the railroads will probably have a critical effect upon future developments. Is the basis of a fair return to be looked upon merely as a theoretical high water mark, to be attained only occasionally and to be instantly followed by increased wages or reduced rates, or both? If so, then after all we shall have made little progress in understanding the stake of modern society in adequate and prosperous railroads.

If on the other hand, the great body of shipper and public opinion remains favorable to the maintenance of present freight levels without serious impairment, then 1926 may well be considered the start of a new era. Investment in railroad securities should become much more attractive. Popular participation in such investment may be expected upon a scale never before seen in this country. This would enable the railroads to greatly increase the number of citizens who become partners in the business and to increase the stability of railroad investment by balancing their capital as between stocks and bonds.

The railroads face the coming year with pride and confidence—pride in those accomplishments which have made them the outstanding leaders in the elimination of industrial waste—and confidence in the friendship and sense of fair play of the American people.

Exhibits at Atlantic City Conventions

Manufacturers and dealers in railway supplies will again exhibit their equipment at Atlantic City, June 9th to 16th, 1926, in conjunction with the conventions of the American Railway Association, Division V—mechanical; and Division VI—purchases and stores.

The Railway Supply Manufacturers' Association, through the office of Secretary-Treasurer J. D. Conway at Pittsburgh, has sent out his official circular No. 1, dated January 9, 1926. This includes a diagram of the exhibit space, with information as to the requirements for membership in the association and how to make application for exhibit space.

In addition to the exhibits on the Million Dollar Pier, there will be the usual track exhibits. Arrangements have also been made for the erection of a special new building directly opposite the Million Dollar Pier for machine tool exhibits. The building will be 400 ft. long by 50 ft. wide, with a center aisle. What was formerly Machinery Hall on the Million Dollar Pier will hereafter be known as Assembly Hall and will be utilized for miscellaneous exhibits. Information may be secured by addressing J. D. Conway, secretary-treasurer, 1841 Oliver Building, Pittsburgh, Pa.

Annual Report of the Chief Locomotive Inspector

The annual report of Mr. A. G. Pack, chief locomotive inspector for the Interstate Commerce Commission has just been issued and, as usual it contains matter that should receive the careful attention of railroad officials.

There is a long list of casualties resulting from the failure of locomotives and tenders and their appurtenances, which when examined appear to be in nearly every instance, to have been the direct consequence of carelessness or neglect. In short they were preventable and would not have occurred had proper supervision and care been exercised.

In regard to this the report says:

"While there was a substantial decrease in the total number of accidents occurring during the year, our investigation shows that a still greater decrease should have resulted had the requirements of the law and rules been complied with, especially so with respect to parts and appliances which are sometimes considered unimportant. Especial attention is directed to the reduction in the number of boiler explosions caused by low water during the year. Boiler explosions are the most prolific source of serious and fatal accidents with which we have to deal, therefore, during the course of our regular work special attention has been given to conditions which contribute to such accidents. A great deal of consideration has been given to the action of the water in the boiler and its effect upon the water indicating appliances and the result of our study in this matter has been brought to the attention of those in charge of locomotive maintenance and operation as well as those actually operating locomotives. The reduction in the number of crownsheet failures as shown is no doubt largely brought about as the result of our study with respect to the circulation of the water in the boiler and its effect upon water glasses and especially upon gauge cocks when screwed directly in the boiler, and to our action in insisting that water indicating appliances and other parts, which may contribute to such accidents, be maintained to a high degree of perfection so that they will perform their functions in a proper manner."

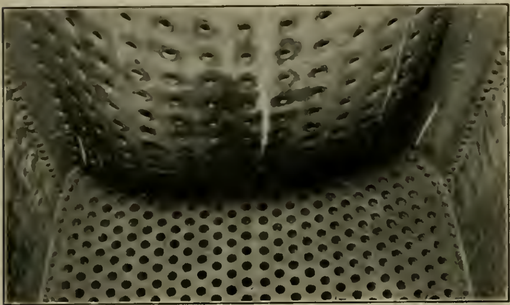


Fig. 1—Failure of Riveted Crown Sheet Due to Low Water

As to the fundamental reason for so many accidents it is stated that "a very large percentage of the accidents which we have investigated were caused by defects which could have been prevented had proper inspections and proper repairs been made at the proper time. Many locomotives are allowed to remain in use in apparent disregard for the requirements of the law sometimes until accidents occur and many times until our inspectors find them and order them out of service."

Among the recommendations made for the betterment of the service there is one which it is strange has not been applied before, and that is for the provision of capable legal assistance and advice. "The necessity for legal assistance is made evident by the apparent disregard on the part of many carriers for the requirements of the law and the rules and regulations established in pursuance thereof until such time as the discrepancies are pointed out to them by this bureau."

"With the large number of locomotives in service, scattered over such a wide area, it is apparent that Congress never intended that the law should be entirely enforced by our inspectors ordering locomotives out of service because of being in violation of the law. It is a physical impossibility for the 65 inspectors now provided to keep in sufficiently close touch with the number of locomotives coming under the jurisdiction of the law to know at all times that they are in condition to meet the requirements thereof.

Therefore, in the light of our experience, I most respectfully recommend that competent legal assistance be provided this bureau so that we may at all times have the benefit of such services in seeing that the law and the rules and regulations issued in pursuance thereof are complied with."

The report again takes up the subject of autogenous welding; touching upon it briefly, but along the lines of the previous reports. A number of accidents in which autogenous welding was involved have been investigated, and the results have served "to establish the soundness of our recommendation, previously announced, that this process has not reached a state of development where it can be safely used on parts of the locomotive or tender where through failure of such parts accident and injury to persons might result."

At the end of the report there are a number of illustrations of accidents, that were investigated by the department, some of which are here reproduced, and in a few instances may be taken as illustrative of the reliability of a properly riveted sheet as compared with one that has been carelessly welded.

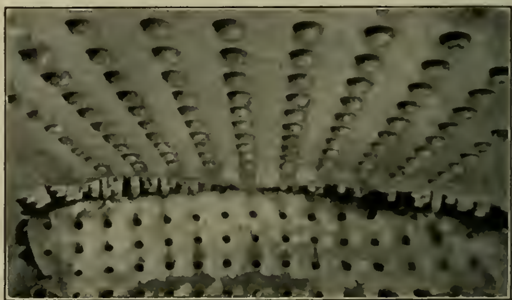


Fig. 2—Failure of Autogenously Welded Crown Sheet

Fig. 1 shows the damage to the firebox crownsheet of a locomotive caused by low water in which all of the seams were riveted. The sheets pulled off from the radial stays and pocketed to a depth of from 20 to 21 inches without other serious damage to the locomotive. These cases with others which have been observed, illustrate the value of having fireboxes constructed in the strongest possible manner.

Fig. 2 shows the result of a crownsheet failure, due to low water which caused serious injury to three persons. The autogenously welded seam between combustion chamber and crown sheet failed for a distance of 51 inches. This boiler was equipped with an automatic fire door,

Fig. 3—A Defective Steam Injector Pipe

which remained closed at the time of the failure, which no doubt greatly lessened the injuries to those in the cab at the time of this accident.

"The seriousness of accidents of this character and previous cases that have been reported is apparent and cannot be overestimated. It is because of such accidents that we have been compelled to take the position that autogenously welded seams within the cab, at or above the cab floor, would not be considered as being in compliance with the law unless the seams are covered with a properly applied patch held in place by rivets, studs or

Fig. 4—Side Rods Rendered Unsafe by Burning Off the Ends to Secure Clearance

patch bolts that would prevent the escape of scalding steam and water in sufficient quantity to cause serious injury should the welded seam fail. This is not held as applying to stoker hole tubes or thimbles where they are welded in the outside sheets: the caulking edge of lapped patches in stayed surfaces; transverse cracks in door hole flanges, nor the ordinary door hole seam which is within the circle of the door hole, unless further developements show that an unsafe condition is created.

Fig. 3 shows a portion of an injector steam pipe which was found in service by our inspector and because of which the locomotive was ordered out of service in accordance with the law. The defective condition of this pipe is apparent and shows gross disregard for safety.

Since the law was enacted 282 accidents resulting in the death of 3 persons and the serious injury of 339 others have been due to injector steam pipe failures, all of which would have been avoided had proper construction, inspection, and repairs been made as required by the law.

Fig. 4 shows two side rods which had been burned off at the ends with a torch to provide clearance, and which unquestionably rendered the rods liable to failure. Such methods show disregard for safety as well as efficient and economical operation.

Fig. 5 shows a drawbar and the safety chains between a locomotive and its tender which failed permitting locomotive and tender to separate and causing fireman to fall to the track resulting in serious injury. The material

Fig. 5—A Crystallized Drawbar and Safety Chains of Insufficient Strength

of the drawbar was crystallized. The safety chains were secured to the tender end sill by two bolts ⅞-inch in diameter which sheared when the drawbar broke. The drawbar and safety chains were said to have been inspected five days prior to the accident and a sworn report made showing them to be in "good" condition. It is apparent that the safety chain attachments were never of ample strength.

These examples which are only a few of those that are gathered in annually by the forces of the locomotive inspection bureau ought to arouse the responsible officials to the necessity of a more careful consideration of original constructions as well as the methods employed in making repairs of parts, whose failure is likely to produce serious casualties.

A New Locomotive for the Texas & Pacific

An Interesting Development of the Lima Locomotive Works

A description was published in the May, 1925, issue of RAILWAY LOCOMOTIVE ENGINEERING of a 2-8-4 locomotive, designated as the A-1 that had been developed by the Lima Locomotive Works. This was followed, in the December, 1925, issue, with a statement of the performances of the locomotive in service and under test, in which great economies and a high efficiency were shown.

The two most prominent characteristics of that locomotive lay in the use of a four-wheeled trailer truck of novel design and a connecting rod so constructed that the main crank pin was relieved of all the stresses that are ordinarily imposed upon it by the resistance to turning of the rear pair of driving wheels.

These and other features of the locomotive made such a favorable impression that even before the tests, described in the December, 1925 issue of this paper, were completed, the Lima Locomotive Works were commissioned to proceed with a still further development of the ideas incorporated in the 2-8-4 engine and design a 2-10-4 locomotive for the Texas & Pacific Ry. This was done and ten of the new type were delivered in November.

The extra pair of driving wheels were necessitated by the additional weight that was to be put upon them, and this, in turn, involved an increase in cylinder dimensions. The diameter was increased from 28 in. to 29 in. and the piston stroke was increased from 30 to 32 in., and the steam pressure was raised to 250 lbs. per sq. in. The tractive effort was thus raised to 83,000 lbs.

The following table gives a comparison of the principal dimensions of the two locomotives:

COMPARISON OF THE TEXAS & PACIFIC 2-10-4 WITH THE LIMA 2-8-4 LOCOMOTIVE

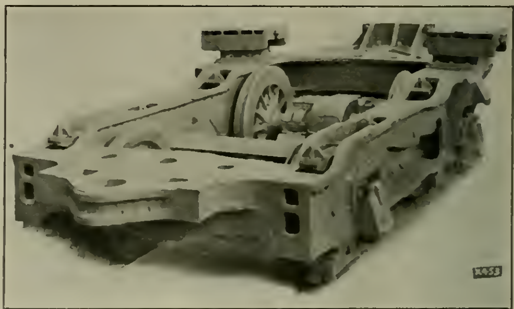
	2-10-4	2-8-4
Cylinders, diameter and stroke, in.	29 by 32	28 by 30
Cut-off in full gear, per cent	60	60
Boiler pressure	250 lb.	240 lb.
Weights in working order:		
On drivers	300,000 lb.	248,000 lb.
Front truck	41,800 lb.	35,500 lb.
Rear truck	106,200 lb.	101,300 lb.
Total engine	448,000 lb.	385,000 lb.
Diameter of drivers	63 in.	63 in.
Heating surfaces:		
Firebox and combustion chamber	473 sq. ft.	337 sq. ft.
Tubes and flues	4,640 sq. ft.	4,773 sq. ft.
Total evaporating	5,113 sq. ft.	5,110 sq. ft.
Superheating	2,100 sq. ft.	2,111 sq. ft.
Combined total	7,213 sq. ft.	7,221 sq. ft.
Grate area	100 sq. ft.	100 sq. ft.
Rated tractive force:		
Engine	83,000 lb.	69,400 lb.
Engine and booster	96,000 lb.	82,600 lb.
Factor of adhesion	3.62	3.58

New 2-10-4 Type Locomotive of the Texas & Pacific Railway Built by Lima Locomotive Works, Inc.

The increase of heating surface in the firebox of the new locomotive is accomplished by means of the use of two Nicholson thermic syphons. This increase of 136 sq. ft. on the basis of Cole's ratios, accounts for approximately 10 per cent more evaporative capacity. Aside from this there are other differences in the design of the boiler. The boiler on the A-1 locomotive had no combustion chamber except that formed by the slope of the throat sheet and the dome was placed on the front course and had an offset opening to which the dry-pipe was attached. In the Texas & Pacific boiler there is a combustion chamber 42 in. long and the dome is set back so that it stands just ahead of the back tube-sheet. It is provided with an inside shut-off valve by which the opening to the dry pipe can be closed. This valve is operated by a stem passing out through the side of the dome with a handle for manipulating it upon the outside.

As with the A-1 locomotive the cylinders are steel castings of the same general shape as those previously illustrated, with outside steam and exhaust connections and having Hunt-Spiller gun iron bushings.

The maximum cut-off is limited to 60 per cent of the stroke at the back but increased to 63 per cent at the front end of the cylinder so as to obtain a smooth starting torque. There are the usual auxiliary starting ports, these which were formerly placed in the bottom of the bushing, have been moved around to the side where they are made accessible for examination and cleaning by the removal of a plug in the outside of the steam chest.



Four Wheel Articulated Trailing Truck of 2-10-4 Type Locomotive Equipped With Booster

As in the A-1 locomotive the main frames terminate just back of the rear drivers and are there hinged to the four-wheeled trailer truck, which transmits the pull of

the engine to the tender. This truck has undergone a modification in some of its details from the original design. In the first place the frame is now formed of a single steel casting, whereas the truck used with the A-1 was built up of two steel castings, the front cross piece and the tail piece and two forged steel side pieces. The use of a single steel casting for forming the whole frame has involved some changes in spring and equalizer arrangements. In the A-1 locomotive, the semi-elliptic journal box springs, with their connecting equalizers, were placed outside the forged slab side frames. In the new structure, the whole frame being in one piece, the side pieces have a sort of semi-box shape and the springs are placed centrally with the frame over the journal boxes and between the two vertical members of the side pieces.

The truck carries the fire-box, the weight being imposed on roller side bearings located over the rear pair of wheels. These bearings give the boiler a free lateral movement to compensate for displacement on curves.

In the previous article descriptive of the A-1 locomotive, an illustrative description was given of the novel construction of the rear end of the connecting rod and of the use of a steel bushing that took the whole thrust of the rod and by which the main crank pin was relieved of all of the thrust required for the turning of the rear pair of drivers, and by which the thrust on the pin was reduced by 25 per cent as compared with what it would have been ordinarily, with four pair of wheels coupled.

The same construction is used on the Texas & Pacific locomotive for the back end of the connecting rod. The side rod leading back from between the forked end of the main rod, is connected to the outer end of the crankpin of the fourth pair of drivers, from the inner end of which an independent side rod leads back to the pin of the fifth pair of drivers. With this arrangement the main crankpin is relieved of 40 per cent of the total thrust of the connecting rod, and the crankpin of the fourth pair of drivers has to carry the total thrust required for the turning of the fourth and fifth pairs. This arrangement permits of a considerable reduction in the diameter of the main crankpin, as compared with what would be ordinarily required, with a moderate increase in the diameter of that of the fourth pair of drivers in order to sustain the extra load put upon it.

As in the case of the A-1 locomotive the booster is coupled to the rear pair of wheels of the four-wheeled truck.

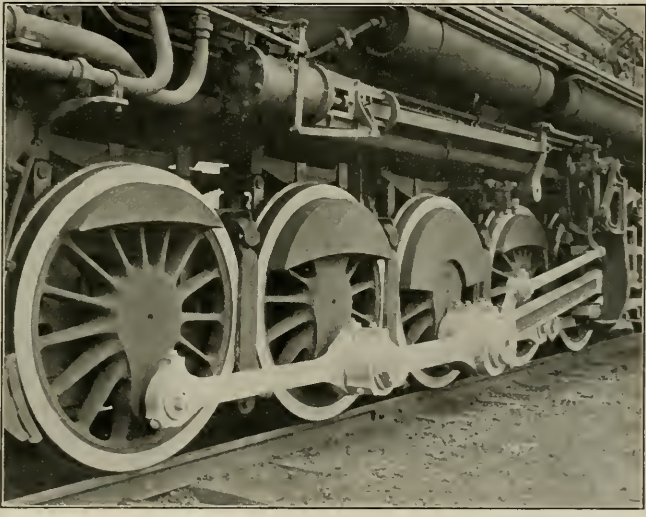
The cylinders and steam chests are lubricated by a four-feed Nathan force feed lubricator and by two of the feeds from a five-feed hydrostatic lubricator connected to the steam pipes. The other three feeds from the hydrostatic lubricator take care of the air pump, the feedwater pump and the booster. In addition to these a National Graphite Company pendulum type graphite lubricator is fitted to deliver into the neck of the superheater header where the saturated steam enters.

Superheated steam is carried back to a turret in the cab whence it is drawn off to supply the air pumps, feedwater pump, headlight generator, the blower, fuel oil heaters, the atomizer, and the whistle.

The use of superheated steam in the whistle raises its tone and intensity. As it is operated by the Parsons pneumatic rigging it can be and is set well forward on the boiler alongside the bell, so as to remove it as far as possible from the cab and thus protect the crew from the disagreeable effects of its high tone.

The steel sheet used for the crownsheet and top of the combustion chamber was rolled in one piece, and, after forming, was butt welded to the side sheets and to the bottom section of the combustion chamber. The tubes used in five of these boilers were of hot rolled, copper bearing seamless steel, supplied by the Pittsburgh Steel Products Co.

Among the details that will probably lessen maintenance costs and keep the weight distribution where it is desired that it should be, will be found the use of case hardened bushings and pins in the spring rigging hangers, with oil holes for the lubrication of the same.



Rod Arrangement on 2-10-4 Type Locomotive, Showing Articulated Main Rod Connection Between Third and Fourth Drivers

These engines are used in freight service on the Fort Worth and Rio Grande divisions between Marshall, Texas and Big Springs a distance of 450 miles where the ruling grades are about 1.5 per cent and have a length of from five to 11 miles. Heavy curvature is also encountered on some portions of these grades necessitating the use of the booster.

Because of the notable economies effected by the A-1 Lima locomotive as compared with its predecessors in the same service, the comparative performance of these Texas & Pacific locomotives, relatively to their predecessors will be looked for with a great deal of interest.

The following is a list of the principal dimensions of these locomotives:

Type	2-10-4
Service	Freight
Cylinders, diameter	29 in.
Piston stroke	32 in.
Valve gear, type	Baker
Valves, piston type, size	14 in.
Maximum travel	8¾ in.
Steam lap	2 7/16 in.
Exhaust clearance	1/16
Cut-off in full gear, per cent	60

Weights in working order:	
On drivers	300,000 lb.
One front truck	41,800 lb.
On trailing truck	106,200 lb.
Total engine	448,000 lb.
Tender	275,200 lb.
Wheel bases:	
Driving	22 ft.
Rigid	16 ft. 6 in.
Total engine	46 ft. 8 in.
Total engine and tender	86 ft. 8 in.
Wheels, diameter outside tires:	
Driving	63 in.
Front truck	33 in.
Trailing truck	36 in. and 43 in.
Journals, diameter and length:	
Driving, main	13 in. by 14 in.
Driving, others	11 in. by 13 in.
Front truck	7 in by 12 in.
Trailing truck	6½ in. by 12 in. / 9 in. by 14 in.
Boiler:	
Type	Taper course
Steam pressure	250 lb.
Fuel, kind	Oil
Diameter, first ring, outside	86½ in.
Firebox, length and width	150⅛ in. by 96¼ in.
Height mud ring to crown sheet, back	60¾ in.
Height mud ring to crown sheet, front	93 in
Arch tubes, number and diameter	2 Syphons
Combustion chamber length	42 in.
Tubes, number and diameter	82—2¼ in.
Flues, number and diameter	184—3½ in.
Length over tube sheets	21 ft. 6 in.
Grate area	No grate
Heating surfaces:	
Firebox and comb. chamber	3,755 sq. ft.
Syphons	98 sq. ft.
Tubes and flues	4,640 sq. ft.
Total evaporative	5,113 sq. ft.
Superheating	2,100 sq. ft.
Comb. evaporative and superheating	7,213 sq. ft.
Tender:	
Style	Rectangular
Water capacity	14,000 gal.
Fuel capacity	5,000 gal.
Rated tractive force	83,000 lb.
Rated tractive force, incl. booster	96,000 lb.
Weight proportions:	
Weight on drivers ÷ total weight engine, per cent	67.0
Weight on drivers ÷ tractive force	3.62
Total weight engine ÷ comb. heat. surface	62.1
Boiler proportions:	
Tractive force ÷ comb. heat. surface	11.5
Tractive force × dia. drivers ÷ comb. heat. surface	725
Firebox heat. surface ÷ grate area	4.73
Firebox heat. surface, per cent of evap. heat surface	9.26
Superheat surface, per cent of evap. heat. surface	41.1

An Oil-Electric Articulated Car

Canadian National Railways Adopts Oil-Electric Equipment Using Lightest Engine of Type in the World and Specially Developed Electrical Equipment

By H. H. FENTON, General Engineer, Westinghouse Electric & Manufacturing Company

A brilliant achievement in the art of transportation has been accomplished by the Canadian National Railways in the design and application of an oil-electric rail car. Branch line and some main line service is becoming more and more important and receiving increasing attention for the purpose of reducing expense and increasing revenue. Passenger traffic has become more frequent. Because of the availability of motor vehicle transportation facilities, passenger traffic has grown to be dissatisfied with the infrequent branch line rail service. The volume of this spread out traffic is insufficient to defray the expense of desired service if it must be met with the customary steam train.

The adoption of the self propelled car for frequent and infrequent light service bolsters up the traffic and reduces the operating and overhead expense as well. The results to be attained with a self propelled car over those of a steam train are far reaching and in many cases difficult of evaluation. Reduction of fuel cost per ton mile is probably the largest single item. Weight on rails, number of trucks pounding over the road bed, elimination of coaling and watering places and attending investment and maintenance are also items of consideration.

Of the self propelled type of car, that one using electrical transmission of power lends itself to the greatest degree of flexibility of service, as well as demanding a minimum of maintenance. Such a car adopted by the Canadian National Railways is known as the oil-electric articulated car. It consists of two bodies, with a total over-all length of 102 feet, set on three four-wheel trucks. The rear end of one and the forward end of the other body are attached to the center truck by means of a safety locking pin. The entrance between cars is protected by a canvas covering in much the same fashion as the vestibule ends of passenger cars on steam trains.

The front unit has three compartments: the engine room occupies 17 ft. 6 in., the baggage room is 16 ft. 8 in. long and the smoking compartment is 15 ft. 9 in. long. The rear passenger unit is 44 ft. long inside. The height from ceiling to floor is 8 feet. The total seating capacity of the articulated car is 126 passengers.

Fully equipped and loaded the articulated car will weigh 100 tons, of which probably 38 per cent is on the forward truck. The trucks are provided with SKF bearings and clasp brakes, and have 36 in. wheels on a 7 ft. 4 in. wheel base.

Engine Is Lightest of Kind in the World

The prime mover is of the Diesel type produced by the William Beardmore & C mpany, Ltd., of London, the original of which was developed under the direction of the British Admiralty for airplane work. The primary modifications consist of dropping from 1,200 to 650 r.p.m, increasing the number of cylinders from six to eight and changing the case from aluminum alloy to steel for rigidity. The cylinders measure 8¼ x 12 in. giving a rating of 340 horsepower at 650 r.p.m. This is the largest engine of its kind in the world outside of areo practice, the total engine weight being only 5,450 pounds. By means of a flexible Bartlett-Haywood coupling the engine is connected to a two-bearing, bracket-type, separately excited shunt generator. The engine-generator unit is mounted on a common vanadium steel bedplate. While the engine is constructed on the Diesel principle it has been adapted in such a way to transportation needs that the name "Diesel" is scarcely a correct description of its type and

the term "Oil Electric" has been adopted for classification purposes. This type of engine is one which depends upon high cylinder compression, approximately 450 pounds per square inch, to secure the temperature of combustion of the fuel, instead of the electrical spark as used in the gasoline engine. Fuel oil is sprayed into the cylinders at a pressure of about 8,000 pounds per square inch. The engine is water-cooled, similar to a gasoline engine. Lubricating oil is forced through the engine at 60 pounds pressure. Both the cooling water and lubricating oil are cooled by radiators mounted on the car roof.

The electrical apparatus, all of which was designed and supplied by the Westinghouse Electric & Manufacturing Company, consists of a 200 Kw., 600-volt, 650-r.p.m., d-c generator direct connected to the oil engine, and four 100-hp., 600-volt railway-type motors with necessary control details. Two motors are mounted on each of the end trucks. A 272-ampere hour 300-volt battery is provided for engine starting and operation of auxiliaries, such as compressors, field excitation, lighting control and signal systems.

The control apparatus is mounted within the engine compartment, located above the generator on a structural iron frame work. The battery is hung from the car underframing of the rear unit and the reverser for the rear pair of motors is mounted withing the rear vestibule. This arrangement of apparatus was selected to cut to an absolute minimum the number of circuits between the two units across the articulated joint. Four main cables cross the truck, the two battery leads and the two power leads to the rear pair of motors.

Full control of the car is centered at the operator's station. The equipment is designed for double end car or train control, with an operator's compartment at each end of the car and the control switches are operated from either compartment so that it is never necessary to reverse the car on a turn-table of "Y." The engine driven generator supplies power for the four propulsion motors, as well as for charging the 300-volt storage battery from which the control and auxiliary circuits are fed on individual 32-volt taps. A duel set of compressors is provided, operated from the 300-volt battery or from the generator in conjunction with a series resistor.

The engine is started and the car operated by manipulating the master controller. The car may be operated either from the generator or the battery. The battery may be charged during car running periods from the 600-volt generator line in conjunction with a series resistor, while during idling time the generator control is such that the battery may be charged without use of the resistor. An emergency system of charging is also provided to care for the small 32-volt sections of the battery.

The car speed is governed by voltage regulation secured by means of adjustment of the field resistor. Remote control of the field is attained by use of an electro-pneumatic drum similar to the sequence drum used in Westinghouse automatic equipments. The constant speed engine drops to idling speed whenever the controller handle is in its "off" position. An electro-pneumatic valve serves to open the throttle and allow the engine to come up to full speed under control of the governor at all times that the controller is in an operating position. By a system of interlocking between the field and generator switches, pneumatic field drum and reversers, faulty operation is prohibited.

The car bodies are built entirely of steel with inside finish of mahogany. The seats are the reversible type, upholstered in Spanish leather and are of sufficient length to accommodate three people on each side of the aisle. This gives a seating capacity of 91 in the rear half and 35 in the smoker, or a total of 126. The car roof is of the turtle back design.

Oil-Electric Articulated Car of the Canadian National Railways

Electric lighting is provided from storage batteries. Both front and rear halves are heated by hot water and ventilation is provided by exhaust type ventilators located in the car roof.

Where the two cars rest on the center truck, each car is provided with a special cast steel end sill to which are bolted male and female center castings, one of which sits within the other, and both engage the truck center plate. By this means each car can swing radially on the center truck and at the same time be securely fastened to the truck with a safety type locking pin, and in addition safety bars are applied.

Performance Record

The oil-electric articulated car is a logical step toward meeting the need for the utilization of a cheap fuel. During the successful testing of the unit a schedule run of 235 miles was accomplished at a fuel cost of $5.87 or a net fuel cost (in barrel lots) of 2.7 cents per 100 ton miles. This is about one-eighth the cost with a steam locomotive and one-fifth the cost with a gasoline car.

On the trial trip the actual running time averaged 52 miles an hour, but the car will attain a maximum speed of 60 miles an hour on the level.

The application of electric drive permits of applying power directly to the axles without the intermediary shaft and attending gearing. This arrangement in turn does away with the high maintenance. In addition, electric drive permits of double end operation which is valuable in many instances of shuttle type service.

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Railway Advancement

It seems fitting at the opening of the new year to cast a retrospective glance at the present condition of the railroads and what they have accomplished for themselves and for the country since the debacle of government control.

The method of small shipments and quick delivery, prevalent in England, has often been set forth for the admiration and goal of imitation to Americans. By it the large inventories of provincial retailers is reduced to a minimum; interest charges are lessened and the flow of raw and finished materials is maintained with healthy regularity. It was considered a dream that such a condition could be brought about in this country; but, according to Mr. Charles S. Keith a large lumber dealer of Kansas City, there is an approximation to such a condition in the south west. In a letter to the president of the Union Pacific, he calls attention to the great reduction in lumber stocks made by the retailers in Missouri, Kansas, Oklahoma and Texas, because of the rapidity with which deliveries are made. He says that, in these states, the retailer is anticipating his requirements by only from seven to eleven days in advance, while in Chicago the anticipation of requirements has been cut down to from twelve days to three weeks, dependent upon the territory from which the shipment is to come. He estimates that this quick delivery has made it possible to have taken at least $600,000,000 out of lumber stocks and accounts in the United States since 1923.

As lumber constitutes only about 8½ per cent of car loadings, it seems fair to assume that other industries have been similarly affected with a consequent enormous saving to the country.

That is one item of effect only, and it will be well to consider some of the means by which this has been brought about.

When the railroads were returned to their owners in 1920 they were in a thoroughly demoralized condition, because of lack of maintenance and the lowering of the morale and discipline of the employes almost to the breaking point. This imposed serious burdens of reorganization as well as the great increase of wages that had been granted under government regime. That they might meet these requirements the transportation act of 1920 was passed. But, even with this, much was left for the railroad managements to accomplish in the way of reducing relative expenses by an increase in efficiency. To accomplish this there has been not only a great advance in the efficiency of locomotive performance but in that of the shops where they are maintained. Machine tools have been wonderfully improved, and those of 20 years ago have been definitely recognized as absolete and too expensive in man power. It is probable that the developments of the automobile industry and the demands made by it on machine tools have been passed along to the railroads whose shops have benefited therefrom to a marked extent.

The improvements made in the locomotive with the resultant economies have also been most marked. For example: during the first seven months of 1925 the fuel consumed per 1,000 ton miles of freight moved was 13 pounds less than it was for the first seven months of 1924, with a consequent saving of $32,971,338. A part of this is attributed to the efficiencies of the brick arch, superheater and feed water heater by Mr. McBride, the former president of the Engineers' Club of Philadelphia. And Julius Kruttschnitt is credited with attributing a 20 per cent increase of efficiency to the superheater.

Then we have the development of new types of locomotives. First to claim attention is the three-cylinder. On one eastern road there is a record of one three-cylinder locomotive replacing two of the two-cylinder type. The Southern Pacific reports that the results from the introduction of the three-cylinder locomotive "have been eminently satisfactory from the traffic point of view, in that the three-cylinder locomotives are capable of hauling 500 more cars per month than similar weight and type two-cylinder locomotives in use on the same road and over the same division."

Then, so far as the improvements in the two-cylinder locomotive is concerned we have the record performances of the Lima 2-8-4 locomotive as presented in the December 1925 issue of RAILWAY AND LOCOMOTIVE ENGINEERING, in which a most notable advance was made over the mikados of 1920. Such performances afford an explanation of the fact that, for the past two years, the railroads have ordered fewer new locomotives than they have scrapped.

This increase of efficiency has been accompanied by an increase in the length of locomotive runs. The New York Central has reduced the number of locomotives used on the New York-Chicago run from nine to three or four. The Southern uses two engines between Washington and Atlanta (637 miles), instead of four; and three engines instead of six between Cincinnati and Jacksonville (840 miles); and three, instead of five between Cincinnati and New Orleans, a distance of 836 miles.

The introduction of a similar policy on the Chicago, Burlington & Quincy has resulted in the release of a number of engines as shown by the following:

Former average daily locomotive mileage..	180
Present average daily locomotive mileage..	252
Miles per day increase..................	72

Percentage increase	40
Locomotives released to other service	23

Touching upon this subject a committee report to the Mechanical Division of the American Railway Association last June said:

"As a result of this experience we have extended this method of operation until we have all main line power, both freight and passenger, assigned to long runs. The only exceptions are the local and branch trains. Our passenger locomotives are now assigned to runs from 483 to 640 miles in length and freight locomotives from 225 to 337 miles.

"From an economical standpoint this method of operation has met our fullest expectation; the saving in locomotive investment and in intermediate terminal improvements and maintenance, and the reduction in the amount of fuel used at intermediate terminals, represents a large saving in our operating costs."

Mingled with and contributing to all this has been the increase of horsepower per unit of weight of the locomotive. For example: about 20 years ago the Pennsylvania Railroad built a consolidation locomotive that weighed about 200 lbs. per horsepower. Recently the same railroad brought out a heavier and more powerful machine that weighed only 105 lbs. per horsepower developed.

Finally we have that latest development, the oil-electric locomotive. As yet winning its spurs in switching service but held up by its promoters as a probable rival of the steam locomotive for road service. And surely if the reports of trials on the Central of New Jersey are borne out in subsequent work the rivalry bids fair to be formidable. According to that statement, an oil-electric locomotive distributed 431 cars on and off 26 floats with a fuel expenditure of $11.90 while the fuel cost of a steam locomotive handling 430 cars on and off the same number of floats was $73.35. Certainly a sufficient difference to attract attention.

If the same rate of improvement is maintained for the next five years as has obtained for the past five, the old locomotives of two decades ago, will appear as the embodiment of a waste that will be beyond all toleration. It is only by such contrasts as this, that we are able to realize the great improvements that have been effected in recent years, and which have almost stolen in upon us unnoticed and unawares.

Possible Locomotive Improvement

It is now about a year and a half since Mr. W. H. Winterrowd of the Lima Locomotive Works read a notable paper before the Mechanical Division of the American Railway Association on the locomotive, in which he prophesied that the substitute for the present locomotive would be one of improved design. Whether it was the implied compliment to locomotive designers as to their ability to advance, cannot be said; but the fact remains that the paper attracted a world-wide attention and was followed by a prolific output of improved designs, that have put the locomotive into a position that would not have been thought possible a few years ago.

When Stephenson designed the multitubular boiler with the exhaust draft he adopted principles of construction of such great and fundamental value that they have been adhered to even since. But many and varied have been the modifications in construction. We have increased engine and boiler efficiency to such an extent that it is difficult to see how further improvements can be made; but we have been in that state of mind before. Possibly the next step may come in the direction of a definite adoption of a higher steam pressure.

Away back in the middle nineties experiments were being made at the Winterthur Works with superheated steam. They attracted little outside attention at the time; but, ten years later, when the principle was being rapidly applied abroad, we awoke to the economies made possible by it and plunged into it, to our great good and advantage.

Now comes the reported satisfactory operation of a boiler built by the Henschels carrying a pressure upward of 850 lbs. per sq. in., and we ourselves are trying a pressure of 350 lbs. in a modest way. The handling of this high pressure, so far as temperature and lubrication is concerned does not present nearly as serious a problem as that encountered at the introduction of superheated steam. At that time, the increase of pressure, with the superheat added, raised our temperatures by about 200 degrees Fahr. or to a total somewhat above 650 degrees. With a steam pressure of 850 lbs. per sq. in. there will be an initial temperature of about 530 degrees which will permit of a superheat of 120 degrees without exceeding our present limits. But there are other problems involved besides those of mere temperature and it need not be expected that the jump of 600 odd pounds per sq. in. in pressure will be made in a day or a year. But we have the possibility before us.

Whether the advance be made in increased pressure, increased expansion, or the attachment of more accessories, we do know that with every advance the possibilities in further improvements in thermal efficiency is narrowed and becomes increasingly difficult of attainment. We are working along a line similar to the asymptote of an hyperbola, which though constantly approaching, will never come into contact with the curve no matter how far it may be extended.

We have moved far along these lines. It is a far cry from the eight-ton locomotive of a century ago to the two hundred-ton monster of today. And we are beginning to feel that our tonnage limits are being reached. Already it has been found that increased capacity can be obtained by other means than an increase of weight. Within the year an increase of approximately ten per cent in boiler capacity has been obtained by a change of proportions without an increase of heating surface, and designers are at work upon other modifications of more or less promise, looking towards a still greater efficiency.

It appears, however, that the real economic gain which will affect the railroads as a whole, lies not so much in a spectacular increase of individual efficiency, as in the raising of old locomotives up to a par with the latest designs that have been brought out.

If, as appears probable, a late change in wheel arrangement will reduce the internal resistances of the engine as a whole, it would appear to be the course of reason to adopt such a wheel arrangement without delay. It is probable that not far from 25 per cent of the indicated horse power developed by a locomotive is consumed in moving the machine over a level track and that even this is exceeded on curves. Here, then, is an opening for a saving, by the reduction of curve resistances and internal friction; and if, as seems probable, these have been reduced by recent developments, certainly the resultant saving is worth looking into.

Then there is the possibility of a saving in operating expenses by a reduction in weight per indicated horse power. We have already dropped below the one-hundred pounds per indicated horse power mark and there seems

to be no good reason why further radical reductions should not be made. It takes one's breath away to think what a locomotive of present-day capacity would weigh if we were dependent, in its construction, on the materials available 40 years ago. So it is not unreasonable to expect that future metallurgical developments will make further weight reductions possible.

We will probably never reach the weight of a pound or so per brake horsepower that was attained by Prof. Langley in one of his early aeroplane engines; but it may, at least, serve as a star at which to shoot.

Here we are then with two definite possibilities in hand. A greatly increased engine efficiency, and a probable decrease in engine resistances that may be applied to engines that are being overhauled. If this were to be done, as it will not be, on the sixty-five thousand odd locomotives of the country, it seems as though the saving of a million dollars a day, said a few years ago to be possible, by the railroads of the country, would become almost an accomplished fact. So, while designers are at work improving the individual locomotive, it will be the part of wisdom to, as far as possible, bring our old engines up to a favorable comparison with those of the latest design.

Safety on American Railroads

The reassuring fact that the railroads of the United States operated 11,250,000 locomotive miles in 1924 before a single passenger was killed, and 287,000 miles before one was injured, was revealed yesterday by Arthur Williams, Vice-President Commercial Relations of the New York Edison Company and President of the American Museum of Safety. The occasion for the statement was the award of the E. H. Harriman Memorial Medals for safety achievement among American railroads at a luncheon given at the Bankers' Club of America by Mr. Williams and James Speyer, Treasurer of the Museum, and attended by Mrs. E. H. Harriman, Mr. and Mrs. E. R. Harriman, and more than seventy railroad presidents and vice-presidents, insurance company executives, government officials, and trustees of the Museum of Safety.

In comparing the railroad accident record of 1914 with that of 1924, Mr. Williams brought out the fact that the railroads are twice as safe now as they were before organized safety work was begun. In 1914 one passenger was killed for every 6,620,000 locomotive miles of operation and one injured for every 116,000.

Practically the same progress was reported in the safety of railroad employees. In 1917, Mr. Williams stated, one railroad employee was killed in an industrial railroad accident for every 9,120,000 man-hours of work, and in 1924 one employee was killed for every 15,550,000 man-hours of work. As for injuries, in 1917 one employee was injured for every 28,000 man-hours of work, and in 1924 one employee was injured for every 48,000 man-hours of work. Such a great decrease in the hazards of railroad work Mr. Williams attributed largely to the influence of the Harriman awards.

The Harriman gold medal for the best record in accident prevention among American railroads for the year 1924 was awarded this year to the Union Pacific System. The medals, first established in 1913, are offered through the American Museum of Safety by Mrs. E. H. Harriman, who was present at the luncheon and personally delivered the prize to E. E. Calvin, vice-president of the Union Pacific System in charge of operations.

The second, or silver, medal, awarded to the division of a railroad which made the best safety record during 1924, was received by C. L. Hinkle, general manager of the Chicago Great Western Railroad, for the Western Division of that company. The third medal, of bronze, offered to an employee of a railroad who individually has been most conspicuous in furthering accident prevention during the year, was awarded to Joseph Kragskow, assistant foreman in the Omaha shops of the Union Pacific System, who in 56 years of continuous railroad service has never received an accidental injury and who more than twenty-five years before the origin of the safety movement had invented several very effective accident prevention devices. Mr. Kragskow, owing to ill health, was unable to be present to receive the award in person.

Honorable mention was also made by the Committee on Awards of the safety record maintained by the Delaware and Hudson Company, and also by the Duluth, Missabe and Northern Railroad, both of which have splendid records for the year. Similar mention was made of H. E. Butler, passenger train conductor of the Nashville, Chattanooga, and St. Louis Railway, who in more than 40 years of railroad work has never been involved in an accident himself nor in any way responsible for accidental injury to another.

Federal Control Cost the Government $1,696,000,000

It cost the government $1,696,000,000 to run the railroads of this country during the 32 months of federal control. This figure was given in a final report submitted December 14 to President Coolidge by James C. Davis, Director General of Railroads, who, at the same time, sent in his resignation.

The 32-month period represents 26 months of war control when the government actually operated the railroads and 6 months "guaranty period." After giving the details of the taking over of the railroads on December 31, 1917, Mr. Davis' report continues in part as follows:

"When the property was returned to its owners claims were presented by the carriers, represented largely by the items of unpaid compensation, undermaintenance of way and equipment, material and supplies and depreciation, in the sum of $1,014,402,446.72. The Railroad Administration set up claims against the railroads, largely for excess expenditures for maintenance, in the sum of $440,353,715.08.

"Congress directed the President, through his agent, as soon as practicable to settle and adjust these and all other claims incident to federal control. Every one of the claims of the carriers whose property was taken over has been adjusted. The creditor roads were paid $243,652,196.91. There was collected from the debtor roads $195,272,295.17. The balance paid by the government was $48,379,901.74, or less than 5 per cent of the claims as originally presented.

"There are perhaps two outstanding features in the adjustment: It was made without litigation, and well within the appropriation originally made by Congress for this purpose. . . .

"Aside from the claims of the railroads for the use of their properties there were innumerable claims of third persons for freight overcharge, reparation, loss and damage, personal injuries, fires, and the like, while the Railroad Administration, on its part, had many claims for demurrage and undercharges. In the neighborhood of 50,000 lawsuits were instituted against the Railroad Administration growing out of these transactions. . . .

"The greater portion of these outside claims have been adjusted, and the entire liquidation is being rapidly concluded. The income of the Railroad Administration from interest on railroad obligations is largely in excess of any amount sufficient to finally conclude this adjustment."

The Reading Company's Gasoline-Electric Car

By T. H. Murphy, General Engineer, Westinghouse Electric & Manufacturing Company

Rising costs of operation and reduced revenue are forcing the railroads to make use of all available methods of transportation. In some cases this means electrification with its ability to handle congested traffic; in others, some form of self-contained unit suitable for service where full trains are not required. Savings in labor, maintenance and fuel make this latter form of transportation unit most suitable for branch line service and main line local service.

Various types of self-contained or self-propelled units have been developed and tried in the past twenty-five years. The gasoline engine outranks the Diesel engine in the number of applications to railroad service in this country, because of its higher stage of perfection, lower cost and lower weight. Several forms of transmission have been tried with each of these, but the reliability. flexibility and ability to handle unlimited power has brought electric transmission to the forefront. Thus, with a field developed by rising costs, and with reliable gasoline engines and tried electrical equipment to place on cars suitable for railroad service, the application of gasoline-electric motive power to cars for railroads was a natural development.

A typical example of such cars is that placed in service on the Trenton Branch of the Reading Railroad. This car is capable of high operating speeds with or without trailers. Trailer operation is not necessary unless traffic conditions are unusually severe, as in addition to the engine compartment the car has a baggage and passenger compartment.

Operation

Since being placed in service this car has been run approximately 16,000 miles. It gives frequent service between Trenton and the main line connection of this branch of the Reading with New York-Philadelphia trains at Trenton Junction. The total run is 3.7 miles. The service is unusually severe as four station stops are made and operation at times is with a standard trailer. Grades up to 1.1 per cent increase the severity of the service. No auxiliary power unit is needed at any time as the gas-electric was designed for the service and is handling it in a very satisfactory manner.

The average schedule time for the one way trip (Trenton to Trenton Junction) is ten minutes. Layovers at each terminal are from 4 to 10 minutes in duration, giving a minimum round trip of 24 minutes. Without layovers the average schedule speed is 22 miles per hour. A total of 21 round trips is made on week days and 23 on Saturdays, giving an average daily mileage of 170. A 110,000 lb. standard steel coach is handled on three of the round trips. This car also handles the switching of express cars at Trenton and the transferring of one 73-ton express car from Trenton to a main line train at the Junction.

This one gas-electric car has replaced two class Q-1, 2-6-4 type steam locomotives and one coach. The locomotives were of special design for operation in either direction and in normal service ran around the cars as the layover time at each terminal was inadequate for turning on a wye. For normal operation of the car no extra movement is necessary as the control is arranged for operation from the rear end and unless a trailer is hauled the operator can run the car from the rear end.

Gasoline-Electric Car in Service on the Reading Railroad

Mechanical Structure

The car was well constructed to meet the exacting demand for a smooth riding, high-speed unit. The weight without load, but with all necessary equipment is 90,000 lb. For operating weight, approximately 10,000 lb. should be added for the average live load.

The car body is of the light-weight steel type, and has straight sides, round ends, arched-type roof, single sash arranged to raise, and is equipped with post castings of spring brass. The under frame consists of a center sill of two 12-inch channels on which the engine generator is mounted longitudinally. Heavy cross members riveted to the center sill support the car body frame. The car body is 60 feet long over the end sills and 9 feet 6 inches wide over the posts. The height from the floor to the roof of the car is 7 feet 10 inches. The over-all height is 12 feet 3½ inches. The engine room, 10 feet 8 inches long, houses a gasoline engine-generator unit and the control apparatus. A baggage compartment is provided which is 11 feet long and 9 feet wide, giving a floor area of almost 100 square feet of which about 16 square feet is occupied by a hot water heater. The main section is a passenger compartment which is 35 feet 10 inches long and has seats for fifty passengers. The seats are of dark brown imitation leather, 40 inch long, and are spaced 2 feet 7 inches. Steel partitions, with a swing-type door, separate the engine room from the baggage room and the baggage room from the passenger compartment.

The trucks have a fixed wheel base of 6 feet 6 inches with 33-inch wheels and are spaced 44 feet 6 inches

between centers. The front pair under the engine-generator set, support approximately 60 per cent of the car weight. The long wheel base and truck center distance and extra heavy trucks were used to give good riding qualities, which are added to by the steel construction used in the under-frame posts and side sheeting.

Motive Power Equipment

The motive power equipment of this car consists of a gasoline engine driven generator, two motors, and suitable control apparatus for reversing the direction of the car and controlling its speed. All units were designed with the idea of obtaining simplicity, reliability, and economy in operation. The car weight and service dictated that an engine capable of delivering 250 horsepower be used with electrical equipment capable of utilizing the total engine power. This fixed the main design factor of the whole equipment. The generator and motors are capable of utilizing the full engine power and the flexibility of the control is such that high speeds without trailers or medium speeds with trailers can be obtained.

The engine power output having been determined from the car weight and service conditions to be met, it was a simple matter to design a gasoline engine capable of delivering the desired power at a reasonably low speed along standard design lines. The engine has a 7¼ inch bore and 8 inch stroke, and delivers 250 horsepower at 1100 rpm. This speed was determined from an engineering standpoint by considering the low weight necessary for such a unit, and also the low maintenance costs that go with low engine speeds. The low speed permits an especially sturdy construction.

The engine has six cylinders, with removable liners and dual heads. It is of the valve-in-head type with two exhaust and two intake valves to each cylinder. The water cooling space around the cylinders is adequate to maintain proper temperatures at all speeds and loads. Trunk type pistons are used with four rings above the wrist pin and one scraper ring. The crankshaft is supported by seven main bearings. It is hollow and arranged so that oil is forced through it to all the main bearings, insuring excellent lubrication.

Two complete ignition systems are provided, by means of two high-tension magnetos with impulse starters used with two complete sets of spark plugs. The magnetos are driven independently and are of the single spark type with manual advance and retard regulation. A centrifugal water pump is used for circulating the cooling water. The oil pump discharges oil to the lubricating oil header. Fuel is supplied by means of a vacuum feed to the carburetor from tanks located under the car.

Two motors are used for engine starting duty. A ring-gear is mounted on the flywheel, and the motors, with Bendix drive, are mounted one on each side of the engine to mesh properly with the ring-gear. The motors are connected in parallel across the terminals of a 32-volt battery when used to turn the engine over. One motor is capable of bringing the engine up to sufficient speed for firing.

The engine cooling water has its temperature regulated by a radiator of the ordinary fin and tube type mounted on the left side of the car. Air is forced through the radiator by a fan, driven by a suitable motor that is connected across the generator whenever the engine is in operation. The quantity of air can be regulated by shutters placed on the radiator.

The generator and engine are mounted as a unit on a common bedplate. A flexible disc coupling with four 16-inch discs is used for connecting them together. The complete power unit is mounted longitudinally in the engine room on the center line of the car. The bedplate is mounted on rubber blocks supported from the center sills of the car body.

The generator is of a special type, designed for service with a gasoline engine in a rail car. An exciter, mounted directly on the shaft of the main machine, is used for exciting the main shunt-field winding and also supplying power at a low voltage for the car lighting circuits and for charging the battery. The shunt field of the exciter receives its excitation from the 32-volt battery.

Each machine has six poles. The main machine operates at 600 volts with normal load at 1100 rpm. and the exciter at voltages up to 60. The principal feature of design is the constant output characteristic of the generator to prevent overloading the engine. It is so satisfactory that the engine runs at constant speed over a wide range of current values, i.e., a wide variation in car tractive effort. The constant output characteristic was obtained by placing a differential series winding on the poles of the execiter and passing the main motor current through it. This gives variations in field strength that are inversely proportional to the current load. The voltage, therefore, drops off in proportion to increases in current demand.

The generator is provided with an extra wide commutator, large brush area and commutating poles to insure good commutation at all loads. Ball bearings effect savings in space and also insure against delays due to bearing failure.

The space and weight limitations imposed by the application demand that the greatest possible ventilation be obtained with a minimum of extra apparatus. The type of application greatly aided in this, as a one-directional fan could be used on the generator shaft, by which large quantities of cooling air are drawn through the machine. It is located at the engine end of the generator and draws the air in over the commutator which is located next to the outer bearing. The location of the commutator facilitates brush inspection.

The generator supplies power to two 140-horsepower motors located on the forward truck of the car. These are standard 600-volt, direct-current motors. They are constructed with solid frames and have openings to permit circulation of air by means of a fan located on the motor shaft. Commutating poles insure good commutation over a wide current range. The motors are axle hung and drive through strong solid helical gears, having a 16:61 ratio, which are totally enclosed and run in grease. This large gear reduction was used to give the high tractive effort necessary with trailer operation.

Control

The control for the Reading car is exceedingly simple. Two unit switches are employed for connecting the motors to the generator, and also a reverser for changing the direction of current flow through the motor fields, and hence the direction of car operation. These are of the electro-pneumatic type usually used for equipments of this size. Their operation is govered by a master controller located conveniently to the operator.

The car speed varies with the generator voltage. This is regulated by governing the engine speed, i.e. the engine throttle setting. A sequence drum with a cam is located on the generator with the necessary push rods to the throttle. The position of the cam determines the throttle setting and hence the engine speed. The movement of the drum is regulated by the same master controller that operates the unit switches and reverser. The operator, therefore, has only one control to use for operating the car. The first movement of the master controller closes the unit switches and also a relay that energizes the

exciter field. Further movement of the master controller only causes further rotation of the sequence drum, i. e. opening of the engine throttle. All the control apparatus, including a number of knife switches for the motors, generators fields and battery circuits, are located on a rack and panel on the generator.

A battery charging regulator is placed between the variable voltage exciter and the 32-volt battery. An additional regulator is placed between the battery and all 32-volt load circuits. A two-directional ammeter is placed convenient to the operator to indicate battery charge and discharge. An oil gage and an engine tachometer are located on the engine. These are readable from the operator's position.

Multiple-Unit Operation

As the sequence drum determines only the engine speed, it is a very easy matter to operate two or more of these cars from one position. It is but a matter of placing the control wires in parallel and notching up the two drums together. A master controller is on the rear end of the Reading car to permit double-end operation. Where continuous operation of a two car train is desired a master controller can be placed on the rear of the trail car and eliminate the necessity of turning the whole unit.

Two air-storage tanks under the car provide compressed air for the air brakes, whistles, bells, sanders and the electro-pneumatic switches and reverser. They are kept charged by a motor-driven compressor having a capacity of 20 cubic feet per minute. This air compressor cuts in and out automatically.

The lighting is furnished by a 160 ampere-hour, 32-volt storage battery which is kept charged by the exciter mounted on the engine generator set. This storage battery also actuates two electric starting motors on the engine. Standard regulators hold the lighting and charging voltage constant.

Performance

The Reading car is capable of speeds up to 51 miles per hour and is able to handle a standard railway coach in regular service. The gear ratio on this type of car determines the maximum speeds that can be attained. Balancing speeds on the level up to 55 miles per hour are possible with smaller reduction between the motors and wheels.

There is a wide field of usefulness for this type of car, as is exemplified by the fact that orders for such equipment have recently been placed by the Boston and Maine, The New York Ontario and Western, The Pennsylvania, The Great Northern, The New York, New Haven and Hartford, and The Erie Railroads. In addition to these cars the Long Island railroad has recently placed an order for a gas-electric switcher, utilizing the power of two engine-generator units with electric motors and the proper control apparatus.

Modern Methods of Staybolt Inspection*

By E. S. Fitzsimmons

Flexible staybolts of various designs had been experimented with, principally in foreign countries, as far back as 1878. Not, however, until about 1890 to 1900 was any active interest shown in this country. During that period rapid progress was made in the development and increased size of locomotive boilers and also increases in boiler pressures first from 140 to 160 pounds; then to 180 pounds, and later to 200 pounds pressure per square inch.

This increase in size and boiler pressure resulted in staybolt breakage to such an extent as to become alarming, and also very expensive. I well recall instances, as no doubt do many others who were directly responsible for boiler conditions while using rigid bolts, of breakage of 75, 80 and 100 bolts in a boiler at a time, these breakages being repeated in the same boilers at frequent intervals.

Experimental installations of flexible staybolts of several designs or types were made on various railroads in several sections of the country prior to 1900, none of which, however, gave any appreciable relief or reduced the trouble sufficiently to cause their general use.

In 1900 the Johnstone bolt, with which most of you are no doubt familiar, was introduced and for a time appeared to be an improvement over earlier types. Though it provided absolutely no means of inspection, it was tried out, as at that time there were no laws governing inspection.

After service tests covering a period of two or three years, it was found that this type was deficient because the head of the bolt became locked in the plug and it was breaking in considerable numbers: and that the absence of any method of inspection made it positively dangerous.

*Abstract from a paper presented at the September, 1925, meeting of the Southern and Southwestern Railway Club.

At a convention of the Master Boiler Makers in 1903, a report was presented by a representative of a railroad having large numbers of these bolts in service, showing that breakage was nearly, if not entirely, as frequent as in the case of rigid bolts and that, upon discovery of this condition, the use of this type was being discontinued. The railroad with which I was connected at that time had a few small trial installations of this type and consequently, when I learned of this report, I personally made investigation by removing some bolts for inspection and found several broken, after which the remainder were removed on account of there being no way of inspecting or determining their condition.

A flexible staybolt of the rounded head design, using a sleeve and a removable cap, was designed by John B. Tate of the Pennsylvania R. R., and introduced to the railroads by the Flannery Bolt Company. In a very short time improvements in the design were necessary to overcome the greatest weaknesses of the Johnstone bolt and an improved type with a clearance space so designed to overcome the objections was presented to the railroads and appeared at a time when the tendency was to even larger boilers, and when breakage of rigid bolts was becoming a serious problem on every railroad. This design gave promise of eliminating many of the weaknesses of former types and provided a means, though an expensive one, of ascertaining the condition of the bolt without removing it from the boiler. For those reasons it was quite generally tried out by many railroads and the results obtained were so generally satisfactory that its adoption and general use almost immediately followed.

In 1905 a committee of the American Railway Association reporting on flexible staybolts said of the flexible staybolt:

"Though of comparatively recent date, it has been received with great favor, indicating the rapidity with which a new bolt of promising design is given a practical trial in the effort to cure the staybolt trouble."

Further in this same report the committee stated the following:

"A simple means of positively detecting cracked and broken bolts is an improvement needed by all flexible bolts that are in service at the present time. The removal of the cap, which will allow an examination of the bolt, is the only absolute means possible with flexible bolts of the present design."

The following years added to the favor with which this bolt was receiced and its general adoption and standardization on nearly all of the American railroads attested to the judgment of its early advocates.

In 1911 the act commonly known as the locomotive boiler inspection law became effective, under authority of which, rules requiring among other things the removal of caps from flexible staybolts for inspection purposes at special stated intervals, were promulgated and enforced.

The generally satisfactory service rendered and the very small percentage of breakage to total number in service (this type having become practically standard) created a doubt in the minds of many railroads mechanical officials of the justification of such a rule or requirement and it was quite generally, and for a time strenuously, opposed. At that time I was opposed to these inspection rules myself.

However, the locomotive inspection bureau through its corps of inspectors had indisputable evidence of the necessity for thorough and regular inspection, for while it was admitted that the percentage of breakage to the total number in service was small, it was shown beyond question of doubt that in certain instances breakages did occur to such an extent as to become a menace to life and property.

In the face of this evidence, opposition to the requirement subsided and in many cases where conditions appeared to be abnormal, many of the carriers voluntarily increased their vigilance and caused inspections to be made at even more frequent intervals than required by the inspection rules.

Investigations were also begun to determine the cause of breakage in an endeavor to apply a remedy. The writer has personally participated in a number of these investigations, the results of which have confirmed the absolute necessity for careful and frequent inspections and have also clearly demonstrated the need of a more accurate and positive method of test than the mere removal of the caps and examination of the bolt heads.

Instances were found where, under bad water conditions, accumulations of scale between the body of the bolt and the inner wall of the sleeve were such as to solidly lock the bolt in the sleeve. The result was to render ineffectual the flexible feature and to cause th bolt to break at the firebox sheet. In a particular instance, this condition resulted in failure to find the defective condition of the bolts when the caps were removed at a regular inspection period and within a few months a disastrous explosion occurred, resulting in the loss of two lives and property damage. Another instance occurred in which the writer did not have an opportunity to participate, but where conditions and results were almost identical, except that in this case, fortunately, no loss of life occurred.

Numerous instances of lesser importance, but all leading to dangerous conditions, have been developed during these investigations and have been made the subject of reports to mechanical officers of the railroads directly affected. The information has also usually been presented to officers of other railroads when a possibility of like conditions appeared probable.

During the past ten years, and more diligently during the past five years, after these abnormal conditions had been prominently developed, constant effort has been made to perfect a method of inspection that would provide greater safety and insure against loss of life, injury to persons, and damage to property.

The first actual service test of such a method was placed in service in August, 1920, in large Mallet type locomotives where abnormal conditions existed and where breakage of flexible bolts was excessive. This method consisted: First, of installation of flexible bolts with telltale holes extending from the firebox end and entirely through the body section and terminating within the bolt head. Second, of testing at regular intervals with a specially constructed instrument to determine definitely that the telltale holes were open and, therefore, operative throughout their entire length. This was accomplished by so constructing the instrument that an electrical circuit would be established when contact was made with the extreme inner end of the telltale hole.

During this service test, two distinct features were developed: First, that moisture, due to temperature changes, condensed in the telltale hole and formed rust or iron exide which gradually increased to such an extent as to interfere with the insertion of the testing instrument. In seeking a remedy for htis condition, various methods were tried, the most satisfactory and the one at present in use being the electro plating of the walls of the telltale hole with copper. Four years' experimental work and service tests have demonstrated the complete success of eliminating the difficulty by this method. Second, that cinder and other foreign matter accumulated in the telltae lholes to such an extent as to require excessive labor to dislodge and remove it in order to permit the insertion of the testing instrument. The cost and time required for this made the method impractical. After numerous experiments it was found that a closure of fireproof porous material applied in the end of the telltale hole prevented the accumulation and at the same time permitted leakage of steam or water in case of fracture, and that it was also readily and cheaply removable to allow insertion of the testing instrument.

During a period of five years tests. on several locomotives of the Mallet type, instances of breakage have occurred and it is interesting to note that in every case the defect was immediately detected through leakage and the bolt was removed before it had entirely broken off, in fact, just as soon as the fracture had penetrated to the telltale hole. On these same engines, on which the tests were made there was not a single flexible bolt that broke entirely off before it was detected.

Similar results from tests on various railroads having trial installations corroborate the findings on earlier tests. These installations comprise over 200,000 bolts on twenty railroads over a period of from one to five years, and in not a single case has any objectionable feature arisen.

During the course of the various investigations, other conditions than accumulation of scale were found to be responsible for flexible bolt breakage. In several distinct cases on four different railroads faulty boiler construction was definitely shown to have been responsible.

Further tests have been conducted to determine the frictional resistance of the bolt head in the sleeve under various loads from normal up to 100 per cent in excess of normal, and it has been found that the frictional resistance increases very materially as the load is increased, and that at 100 per cent over load, the frictional resistance increases to 125 per cent or more. With this increased frictional resistance and the excessive bending stresses

caused by distortion of the boiler plates, the stresses in the outer fibres of the bolt material are so high as to cause the breakage under the head.

It is believed it will be conceded that, under such adverse conditions, no bolt may be expected to render long service.

This condition actualy exists on a large number of boilers and we feel certain that none of you are undecided as to the results that may be expected from such conditions and that, after convincing yourselves of such conditions, that there will be no doubt in your minds as to the necessity for a positive and constant indication of the soundness of the bolts being used to stay such boilers.

The remedy obviously is to correct the error in construction. The best evidence of this fact is that boilers of like design and even larger in size have been in service for the past ten years and are still in service with no difficulty being experienced from bolt breakage.

Having shown in the foregoing the necessity for a better and more positive means of inspection of locomotive boiler flexible staybolts, an explanation will be given of the application of telltale flexible staybolts and a method for their inspection, which provides a maximum of safety and efficiency with a minimum of maintenance and inspection costs, which also eliminates a large loss of engine service consumed by the present stripping and cap removal method.

Under the old cap removal method, the condition of the bolt can only be determined or known definitely on the particular day or days that the cap is off and under unfavorable conditions such as previously described even then it may be doubtful. During the remainder of the two year interval between cap removal, little or no knowledge is available as to the condition of the bolts. Some inspectors claim to be able to detect broken flexible bolts under hammer test without applying pressure to the boiler. Having had thirty-five years' experience in boiler construction and maintenance, I would caution responsible officials against placing too much credence in such claims.

The telltale flexible bolt is identically the same as the Tate bolt described heretofore, with the addition of a telltale hole extending through the entire length of the body section and terminating within the head of the bolt. The walls of the telltale hole are copper plated to prevent rust or corrosion within the hole and to prevent them from becoming closed from this cause. They are applied exactly the same as the ordinary flexible bolt. If the method of riveting closes the end of the hole, it may be reopened easily and quickly, after which a porous fireproof closure is applied that will prevent the accumulation of foreign matter from the telltale hole, and that will permit leakage of steam or water in case of a break or fracture, which serves as a daily indicator of the condition of the bolt. This feature provides a daily or constant, positive indication by this method, as compared to questionable information once in two years by the old cap removal method.

In addition to depending on the leakage through the telltale hole, an inexpensive method of periodically checking up the condition of the telltale hole is provided as follows:

The fireproof porous closure is first removed, after which the specially constructed testing instrument is inserted. Upon reaching the extreme end of the telltale hole and making contact therewith, a light flashes in the handle of the tester indicating that the hole is open and therefore operative throughout its entire length.

The method of testing has been built upon the fact that a broken bolt having a telltale hole will show leakage of water or steam, providing the telltale hole is open and operative and that it extends to every part of the bolt.

The tester is so designed and constructed that it will positively indicate whether or not the telltale holes are open throughout their entire length. After inserting the tester in each telltale hole and securing light in the handle (which indicates that contact has been made with the extreme inner end of the hole) if the bolt is broken, or fractured into the hole, leakage will positively occur when water pressure is applied to the boiler.

Whentesting for broken staybolts first break through the porous closure with a sharp pointed pin or punch and a light hammer, then blow all of the remaining particles out of the telltale hole with the tool provided with the testing equipment for that purpose. Attach the ground connection in any convenient telltale hole, then insert the test rod into each telltale hole until contact with the end of each hole is secured. Such contact is indicated by the lighting of the bulb in the tester handle.

After contact has been secured in each and every bolt, apply water pressure to the boiler and every defective bolt will be indicated by leakage through the telltale hole. If no defective bolts are found, or after replacing any that are found, again close the telltale hole with the fireproof porous material and the engine is ready for service.

Cases may occur where breakage or fracture will be indicated by leakage and will not be observed or detected at the time they develop, as for instance in engines in pusher service at isolated points or bolts located behind brick arches, grate bars, etc., and in which the telltale hole will gradually become filled by accumulation of scale from the boiler water. Therefore, whenever the tester is inserted, it strikes an obstruction and fails to show a light in the handle. In such cases the tester should be removed and a special cleaning drill applied to remove the obstruction. After drilling, blow clean with the air tool, re-insert the tester, and if the hole has been thoroughly cleaned, contact will be secured and indicated by the lighting of the bulb as before described, and when water pressure is applied, leakage will occur.

Securing contact in the telltale hole does not indicate that the bolt is in good condition, but only that the tellale hole is open and operative throughout its entire length. It is the failure of the bolt to leak under pressure after contact has been obtained which indicates that it is not broken.

With this description of the method and use and comparison of results, we will now proceed to a comparison of costs. These comparisons are based on actual timed tests by both the old and new methods and the figures quoted are accurate and authentic.

The present method of inspection requires from three to four or more days, the principal part of the work being the removal and replacement of parts, rather than the actual time required by the inspector to examine the bolts.

By the new method herein described, it is not necessary to touch or remove anything on the outside of the boiler and the entire test on a modern locomotive boiler containing a full installation of flexible bolts can be completed within an eight-hour day—and at a labor cost of from \$10 to \$20, depending on the size of the installation.

The cost to strip, remove caps, inspect, and replace runs from \$100 to \$250, depending upon the size of the locomotive and upon the facilities at hand, and in addition, results in two, three, and sometimes more, days loss of engine service.

A number of railroads have been using the new method of inspection just described for some time, irrespective of the fact that the government had not yet approved

same, because they were convinced that it added such an immeasurably increased factor of safety that it would more than compensate for the additional cost of this method of testing in addition to complying with the Interstate Commerce Commission rules that require the removal of caps every two years. The locomotive inspection bureau, however, has been fully aware of the use of this new method for the last four or five years, has been checking up the results very carefully, and when a number of the railroads that have been using this method of inspection for some time made an application for a modification of Rule 23, careful consideration was given to same with the result that, at a general session of the Interstate Commerce Commission held at its office in Washington on July 28, 1925, it was ordered that Rule 23, as approved in the order of the Commission entered April 7, 1919, be, and the same is, hereby amended to read as follows:

"23. *Methods of testing flexible staybolts with caps.* Except as provided in paragraph b, all staybolts having caps over the outer ends shall have the caps removed at least once every two (2) years and the bolts and sleeves examined for breakage. Each time the hydrostatic test is applied, the hammer test required by rules 21 and 22 shall be made while the boiler is under hydrostatic pressure not less than the allowed working pressure.

"(b) When all flexible staybolts with which any boiler is equipped are provided with a telltale hole not less than three-sixteenths (3-16) inch nor more than seven thirty-seconds (7-32) inch in diameter, extending the entire length of the bolt and into the head not less than one-third (1-3) of its diameter and these holes are protected from becoming closed by rust and corrosion by copper plating or other approved method, and are opened and tested, each time the hydrostatic test is applied, with an electrical or other instrument approved by the bureau of locomotive inspection, that will positively indicate when the telltale holes are open their entire length, the caps will not be required to be removed. When this test is completed, the hydrostatic test must be applied and all staybolts removed which show leakage through the telltale holes.

"The inner ends of the telltale holes must be kept closed with a fireproof porous material that will exclude foreign matter and permit leakage of steam or water, if the bolt is broken or fractured, into the telltale hole. When this test is completed, the ends of the telltale holes shall be closed with material of different color than that removed and a record kept of colors used.

"(c) The removal of flexible stay bolt caps and other tests shall be reported on the report of inspection Form No. 3, and a proper record kept in the office of the railroad company of the inspections and tests made.

"(d) Fire box sheets must be carefully examined at least once every month for mud burn, bulging, and indication of broken stay bolts.

"(e) Stay bolt caps shall be removed or any of the above tests made whenever the United States inspector or the railroad company's inspector considers it desirable in order to thoroughly determine the conditions of staybolts or stay bolt sleeves."

Nominations for I. C. C. Membership

The nomination of Thomas L. Woodlock of New York to be a member of the Interstate Commerce Commission was resubmitted to the Senate by President Coolidge, December 21. At the same time the President announced the resignation of Commissioner Charles C. McChord and nominated Richard V. Taylor of Alabama to succeed him.

Mr. McChord has been a member of the commission since 1910, having been re-appointed in 1915 and again in 1922. He was also chairman of the commission in 1915 and again in 1922. For some time he has been a member of Division 1 of the commission which has general jurisdiction over matters pertaining to valuation, safety, locomotive inspection, block signals and train control. Mr. McChord was born December 3, 1859, at Springfield, Ky., and was educated at Center College at Danville, Ky. He engaged in the practice of law and from 1886 to 1892 was prosecuting attorney at Springfield. In May, 1892, he was appointed a member of the Kentucky Railroad Commission, of which he became chairman.

Mr. Woodlock has been serving on the Commission under a recess appointment following the failure of the Senate in the last session to confirm his nomination.

Mr. Taylor has long been connected with transportation. He began his railroad career in 1877 as junior clerk in the accounting department of the Mobile & Ohio Railroad. By 1904 he had worked his way up to the position of general auditor and in that year was promoted to be general manager of the railroad. Later he became Vice-President in charge of operations.

During the period of federal control he served as Federal Manager of the Mobile & Ohio Railroad, of the Southern Railway in Mississippi and of the Gulf, Mobile & Northern Railroad.

Following the war period Mr. Taylor entered the shipping business in Mobile. In 1921 he was selected to fill the unexpired term of one of three City Commissioners of that city. A year later he was elected mayor of the city and last September was re-elected a commissioner for a full six-year term.

An American Museum of Engineering

Plans to establish a National Museum of Engineering and Industry, which have been receiving much thought among engineers for years past, are now assuming more definite form and the project seems to be on the high road to realization. One of the latest and most important accessions to the movement is Samuel Insull, of Chicago, Ill., now President of its Board of Trustees, a man whose experience and enthusiasm will be invaluable in the difficult task of placing such an important institution on a substantial basis.

As outlined by preliminary studies, this Museum would be patterned after those long established and highly successful ones in England, Germany, and elsewhere on the Continent. It would be a storehouse, a treasury, of historic engineering models, instruments, plans, and accomplishments. It would be more than a source of delight and of interest; it would be an inspiration to every visitor.

A natural seat for such a museum would seem to be in Washington, D. C., possibly in close connection with or under the administration of the Smithsonian Institute, although other considerations might well be argued in favor of certain other prominent cities; but the ambitions of those in close touch with the proposal go even further and anticipate branch or co-ordinate museums in all the principal cities. These extensive plans and the physical details of the noble building visioned as the central museum are expected to engage the immediate attention of the Board.

All American engineers will find pride in watching the growth under most favorable auspices of an institution which conserves and in a sense glorifies the achievements of their profession.

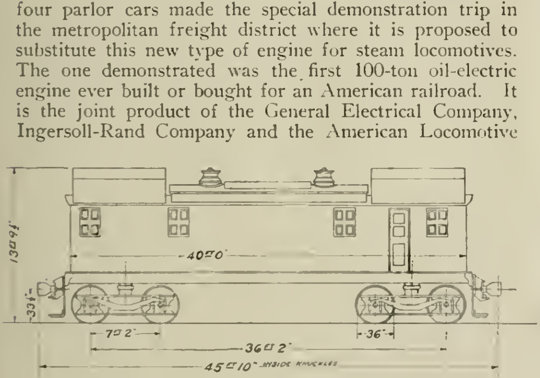
100-Ton Oil-Electric Switching Locomotive of the Long Island Railroad

Over 100 prominent railway officers, engineers and railway supply men on the invitation of George LeBoutillier, vice-president of the Long Island Railroad Co., attended on Tuesday, December 22, the first public demonstration of the new 100-ton oil-electric locomotive, which is being used in switching service on that road.

This locomotive was described in some detail in the November, 1925, issue of *Railway and Locomotive Engineering*.

100-Ton Oil-Electric Switching Locomotive in Service on the Long Island Railroad

A special train with the guests of the railroad occupying four parlor cars made the special demonstration trip in the metropolitan freight district where it is proposed to substitute this new type of engine for steam locomotives. The one demonstrated was the first 100-ton oil-electric engine ever built or bought for an American railroad. It is the joint product of the General Electrical Company, Ingersoll-Rand Company and the American Locomotive Company, who were also the builders of the 60-ton oil-electric locomotive which has been in service for some time on the Central Railroad of New Jersey. It is understood that orders for locomotives of this type have also been placed by other eastern and middle-western railway companies.

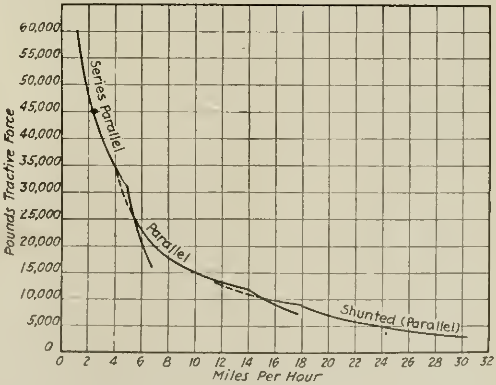


100-Ton Oil Electric Switching Locomotive

The principle of the oil-electric locomotive is an internal combustion oil engine, which drives an electric generator, the current from which is applied to motors on the axles of the locomotives. The heavy oil engine has effected astonishing economies in the operation of ships and of land industrial plants during the last few years, and its advent into the railroad field promises, according to engineering authorities, to mark a new milestone in the history of American transportation.

Regulation of the speed and tractive force delivered is illustrated by the speed tractive force curve shown on the accompanying chart. Referring to this chart it will be noted that the locomotive develops a tractive force of 60,000 lbs. at 30 per cent, the factor of adhesion maintained to approximately one mile per hour. At ten miles per hour the locomotive develops a tractive force of 15,000 lbs.

The air brake equipment consists of the Westinghouse,



Speed-Tractive Force Curve of 100-Ton Oil-Electric Locomotive

schedule EL-14, straigth and automatic air brake. The foundation brake rigging is designed to give a total brake shoe pressure of 60 per cent of the weight on the drivers with a 50-lb. cylinder pressure. The brake cylinder is 18 in. by 12 in. An air compressor for providing air for braking is installed in the cab. It has a piston displacement, when working against 130 lb. pressure and

at 600 volts, of 100 cu. ft. per min. It will deliver air at a pressure of 90 lb. or 140 lb. per sq. in.

The running gear consists of two four-wheel, swivel, equalized trucks, each of which is equipped with a cast steel bolster and steel side frames. The side frames are carried on semi-elliptic springs to the equalizers which are in turn carried on the journal boxes. The journal boxes are of cast steel, pedestal type with A. R. A. bearing and wedge. With the exception of the truck equalizers axles and that part of the traction motors carried on the axle, the entire weight of the locomotive is spring supported and equally distributed over the four pair of drivers. The axles are of forged open-hearth steel and have 6½ in. by 12 in. journals.

Test of Long Island 100-ton oil-electric locomotive

Start of test—Pennsylvania enginehouse, Erie, Pa.	7:15 A. M. Dec. 15
Conclusion of test—Pennsylvania freight terminal, Greenville, N. J.	11:38 P. M. Dec. 16
Trailing load	5 box cars, 1 passenger coach, 1 caboose
Total train weight, including locomotive	377 tons
Miles traveled	537
Total time elapsed	40 hr. 123 min. 45 sec.
Actual running time	28 hr. 44 min. 45 sec.
Total detention	11 hr. 39 min.
Average speed	18.7 m.p.h
Maximum speed	30 m.p.h.
Total kw. hrs. generated	3810
Average oil engine load factor, per cent.	23.6
Maximum oil engine load factor, per cent	74.1
Total fuel oil consumed, gallons	473
Total lubricating oil consumed, gallons	5
Total water consumed, gallons	negligible
Total ton-miles	202,249
Total oil cost (fuel oil at 5 cents per gal., and lubricating oil at 50 cents per gal.)	$26.15
Fuel cost per 1,000 ton-miles, cents	12.90
Fuel cost per locomotive mile, cents	4.86
Fuel cost per kw.-hr. generated, cents	.685
Average fuel oil per kw-hr. generated, lbs.	.895
Average fuel oil per locomotive mile, lbs.	6.35
Average fuel oil per 1,000 ton-mile, lbs.	16.85

Dimensions and proportions of Long Island 100 ton oil-electric locomotive No. 401

Type	Oil-electric
Service	Switching
Weights on drivers	200,000 lb.
Wheel bases:	
Truck	7 ft. 2 in.
Total locomotive	36 ft. 2 in.
Oil engines:	
Number	2
Type	Ingersoll-Rand, 6 cyl, 4 cycle, vertical.
Rated capacity	600 h. p.
Cylinders, diameter and stroke	10 in by 12 in.
Speed	600 r.p.m.
Piston Speed	1,200 ft. per min.
Fuel	Fuel oil
Generators:	
Number	2
Type	General Electric, Type TDC-6, 200 kw. d.c., 600 r.p.m. volt
Exciter	6 kw., direct connected, 60 volt
Voltage, variation	200—750 volts
Motors:	
Number	4
Type	General Electric. Type GE-69-C, 20 h.p. 600 volts
Capacity of fuel tanks	400 gals.
Length over couplers	45 ft. 10 in.
Diameter of wheels	36 in.
Size of journals	6½ in. by 12 in.
Tractive force	60,00 lb. at 20 per cent factor of adhesion maintained to approx. 1 m.p.h.

Fuel Records Established

In a trip of 537 miles from Erie, Pa., to New York, it established a record by completing the longest run ever made in this country by an oil-electric locomotive hauling a loaded freight train. The run was made primarily for the purpose of delivering the locomotive to the lines of the Long Island Railroad. A further record was made in that no fuel or water was taken on during the trip. A low-grade fuel oil, costing now five cents a gallon, is used in the operation of the locomotive, and the total cost of both fuel and lubricating oil for the 537-mile run was only $26.15. The average fuel cost per mile was only 4.6 cents. The total fuel cost per kilowatt hour generated was 2-3 of a cent. Further details of its performances record on the run are given in the accompanying table.

Performance on Grades

The locomotive, with its loaded train, made all grades with ease, the steepest being one of one and six-tenths per cent for a distance of eight miles out of Erie. At Wildcat Crossing, a point about 86 miles east of Erie, the oil-electric locomotive was brought to a stop by the engineer, and then started, from a standstill, up a grade of one and three-tenths per cent.

This type locomtive has some very definite operating advantages. It is smokeless and its engine presents the well recognized economy of the internal combustion engine. As a consequence of this economy, the fuel tanks can carry sufficient fuel for a long continued service and the loss of time required for taking on fuel and water during service is thereby eliminated.

Mechanical Division Adopts Standard Double Sheathed Wood Sheathed Box Cars

Two designs of double sheathed, wood sheathed standard box cars presented at the annual meeting of the Mechanical division of the American Railway Association by the Committee on Car Construction have been submitted to letter ballot and adopted by an overwhelming majority of the membership. Members numbering 313 and representing 2,450,755 cars owned or controlled, voted in favor of the proposed standard designs, with seven members representing 46,830 cars opposing, and 89 members representing 250,452 cars not voting. The results of this letter ballot are given in Circular D. V.-434. In addition to the adoption of standard car designs, the association has approved as recommended practice specifications for side frames and bolsters, coupler yokes and hatch plugs for refrigerator cars as recommended by the committee. The minimum heel seat diameter of axle with 4½-in. by 8-in. journals is increased to 5¾ in., and the total load for car and lading established at 116,000 lb., this change requiring an amendment to the Interchange Rules of the Division which is approved, effective January 1, 1926. The proposition to withdraw the present bolster drawings shown in the manual and substitute the new bolsters shown with the standard car drawings is approved, effective March 1, 1926.

The results of five other letter ballots recently submitted to members of the Mechanical division have been tabulated and published in Circulars D. V.-429, relating to brakes and brake equipment; D. V.-430, couplers; D. V.-431, specifications for tests for materials; D. V.-432, wheels; and D. V.-433, loading rules. In each case the recommendations of the committees in their reports at the June meeting at Chicago were adopted by large majorities.

Snap Shots—By the Wanderer

The locomotive, that is the American locomotive has long since ceased to be a thing of beauty. There was a time when they were at least considered beautiful, fantastic as was their ornamentation, but that was in accord with the taste of the times. There was so little to the machine that its very enforced simplicity of construction, gave it an attractive appearance despite the ogees and heading and mouldings with which it was encumbered. But, in general its lines were smooth and straight. There were no accessories, just a plain boiler with a pair of engines and everything as accessible as the most captious could desire. The first excressence was the air pump, but the small affair of those days was not very prominent tucked away on the left hand side. Then we started in on the cab and put in a water column; a turret, a hydrostatic lubricator, first with two deliveries, that have grown to six and eight. Then there are door openers and stokers, and injectors, until the back head is covered with a labyrinth of piping and accessories; enough to puzzle any but the very elect. These are of the cab. The big accessories are on the outside and they are fastened on wherever there is space for their accommodation. The only observed rule is that they be kept away from the right hand side so as to avoid unnecessarily obstructing the view of the engineer. But, barring this, the air pumps have crawled all over the left hand side and front end of the boiler. And these modern duplex pumps are not the modest affairs of three or four decades ago, but great engines with large cylinders that require much space and substantial fastenings. To these, for there may be two of them, there is added another big affair, the feed pump. This has not yet wandered far from the center of the left hand side, but there is no telling as to where its destination may be. Then there is the main reservoir, already become a plural. Its cosy place beneath the running board has been pre-empted, and it too has become a wanderer on the face of the locomotive. Now we find it beneath the boiler and between the frames. Now it has crawled out and come to a temporary resting place on the pilot. Ousted from there, by a feedwater heater it has jumped, at least one of them has, again to be followed by the heater, to the top of the smokebox, jostling the headlight from its time honored position, which, in falling, has landed on a bracket in the middle of the smokebox door. The bell has deserted its time-honored place between the sand box and the smokestack and may be anywhere. So that our locomotives are covered with a helter skelter mass of excrescences that make for anything but seemliness of appearance.

But, for the most part, we have clung to accessibility and it speaks well for our designers that with this great mass of extraneous matter, plastered all over the engine, the individual items are, nearly always quite accessible individually and can usually be removed, repaired and replaced without disturbing other things. This certainly makes for cheaper maintenance than if attention had been directed towards the keeping of piping concealed beneath the jacketing and covering up the larger pieces so as to give the locomotive a smoothness of finish that would make it more pleasing to the eye. Perhaps, sometime, when we get through adding accessories for the increase of efficiency we may find the time to look to beauty of outline and accomplish it without sacrificing our valuable asset of accessibility.

I am beginning to have a great deal of sympathy for the old fogy. And I hardly like the dictionary definition of him, which says that he is "an old-fashioned eccentric. A singular person," if to be eccentric, is to be out of the ordinary, I can hardly agree, for most of us are old-fashioned, and if the majority are such, then that cannot be out of the ordinary. We accept our customs, our religion and our morals from the teachings of an ignorant past and the older they are and the less they are supported by scientific data the more we cling to them.

But, after all, isn't that a comfortable and satisfactory way of thinking. It is exemplified by the speech of an old manufacturer to a young engineer friend of mine who had just entered his service. The youngster started to poke into some shop practices that did not seem to him to be just the thing when he was brought up with a round turn by: "Now Mr. B—— don't you go tryin' no oxperiments."

It is so comfortable, or at least it would be if we could only build locomotives just as we did when we learned our trade. They pulled all the train required of them so why demand more? Their rods and straps all draw filed, and the files so nicely chalked. What's the use of learning a trade if you will be obliged to abandon all of its nice little quirks and turns before your hair starts to gray?

Then why not stick to one style of motive power? It works all right. What is the sense of getting the mind all mixed up with steam locomotives, electric locomotives, multiple unit control, gasoline-electric, Diesel-electric, internal combustion direct drive and the Lord knows what else? When we had a locomotive with the Stephenson gear, and nothing in the cab but the two levers, three gauge cocks, one steam gauge and a whistle lever, why a man could make some pretense of knowing all about a locomotive. But now, he has a hundred and one things to look after and each one has an especially trained nurse. The air pumps, the triple valves, the injectors, the front end, the etc., etc. You get dizzy thinking of them, and when it comes to knowing much of anything about the various types of motive power that are trying to crowd the locomotive off the rails, why, you simply can't do it. So there you are. You can't do it. Then, why try? Just be an old foggy. Settle back in your easy chair, and refuse to attempt to learn the ins and outs of these newfangled creations. Take your ease and refuse to be stirred by the madly rushing crowd that is sweeping past you. Just rest content for a year or two and you will be left alone in the quiet and complacent past. So far behind the times that it will be a hopeless task to try and catch up. Then you will be a real happy old foggy quite enviable in your content.

So, while we may laugh and perhaps scoff at the old foggy, hasn't he really got the better of us who are eternally trying to keep up with or improve on what has gone before? Even if we are in the front in the evening, we will awake in the morning to find that some sleepless fellow has forged ahead of us in the small hours of the night.

Is there anything of which this is not true? Locomotives, cars, rails, stations and every appliance that goes into the making of them? The old slang expression of "Give us a rest," can well become the heartfelt prayer of each and every one of us.

The old English method of apprenticeship indenture, under which a boy became a virtual slave for a term of years in return for the instruction that he received in his selected trade, has passed forever, and in its place has come the modern method of pay and teach, with the

expectation that enough of the journeymen so trained will remain with the master to make the system worth while.

I do not know that the railroads are leaders in their methods and results, but they are certainly the leaders in the publicity, which they give to what they are doing.

A forefront example of the work of this character is probably to be found on the Atchison, Topeka and Santa Fe. Here results seem to be all that can be asked; for when shops employing upwards of three thousand men can make their own mechanics so plentifully and successfully that they can run for years without going outside for mechanics, it speaks well for the system developed and used.

It seems to me that it also speaks very well not only for the character of the apprentices themselves but also for that of their parents; and a statement as to the assistance that the railroad receives from the parents in holding the boys to the jobs, would be most interesting.

A somewhat extensive opportunity for observation has led me to believe that the mother is a serious, if not the most serious obstacle to a boy's sticking to his job through the four long years of apprenticeship.

The glamor of novelty soon wears off and the boy, with a boy's love of change thinks that some other trade would be much pleasanter and—easier to learn than the one he has started upon. So he takes his mother into his confidence, and when she sees how tired and dirty he is, when he returns at night, her sympatheties are aroused, and she is quite ready to cast about with him for something that seems, from the unknown outside, to offer less of labor and more of reward. So even before a second choice has been made, the boy fails to appear some morning, and a few days later his mother may call to ask if any pay is due him, and explain that he isn't very strong, and that she didn't know the work would be so hard. And there is one more lad started on an untrained life. So, as I said, the results obtained on the Atchison seem to me to speak well for the general run of the parents of the apprentices who have entered the service of the company.

1926 Brussels International and Commercial Fair

The Official Brussels Commercial Fair, the seventh of its kind, will be held in Brussels from April 7th to April 21st, 1926 (inclusive).

The statistics of the importance of this organization reveal the great interest manifested by foreign firms.

The Fair of 1920, the first to be held, had only 1,602 participants, 429 of which were foreigners; the 1925 Fair had 2,853 exhibitors of which 920 were foreigners. These figures suffice to show the benefit American producers would enjoy in participating in this exhibit. It may be added that American products are highly praised in Belgium for their quality and their finish.

The Official Brussels Commercial Fair gives producers the opportunity to display their ware and specialties to buyers from all countries; merchants, for their part, are sure of finding at the Fair, on most advantageous conditions, the finest selection of articles, displaying the very latest improvements known to technical science and derived from world-wide experiment. The Commercial Fair is for all persons concerned, whether buyers or sellers, a saving of effort, time and money.

Belgium is very centrally located, and buyers from all Europe flock to these annual exhibits.

Full particulars about official regulations at the Fair, insurance, advertising, form of application for space, etc., can be obtained by addressing such request to the Executive Committee, 19 Grand Place, Brussels, Belgium, or at the Belgian Consulate in New York City, 25 Madison Avenue. It will be advisable to give notice of prospective exhibits as early as possible in order to obtain the best reservations and proper listing in the Official Catalogue of the Fair.

Strathcona Memorial Fellowships in Transportation

Five Strathcona Memorial Fellowships in Transportation, one thousand dollars each, are offered annually for advanced work in transportation, with special reference to the construction, equipment, and operation of railroads, and other engineering problems connected with the efficient transportation of passengers and freight as well as the financial and legislative questions involved. Transportation by water, highways, or airways, and the appropriate apparatus involved, and also other general aspects of the broad field of transportation, embracing its legal and economic phases, will be included in the list of subjects which the Fellows may select for investigation and study. The holder of a fellowship must be a man who has obtained his first degree from an institution of high standing. In making the award, preference is given, in accordance with the will of Lord Strathcona, to such persons or to the sons of such persons as have been, for at least two years, connected in some manner with the railways of the Northwest.

Applications for these fellowships should be addressed to the Dean of the Graduate School of Yale University, New Haven, Connecticut, before April 1, on blanks which may be obtained from him. Applicants must submit with their application a brief biography, and a certified record of their previous courses of study in college or technical school, and their standing therein. They should also submit testimonials bearing upon their qualifications. A recent photograph of the applicant is requested.

Various courses of study relating to transportation along engineering, economic, and legal lines are now offered by Yale University. For greater particularity the applicant is referred to the Catalogue of the Yale University Graduate School, and especially to details found under the following groups and courses of study, viz.: Social and Political Science; Government and Public Law; Civil Engineering; Electrical Engineering; Mechanical Engineering; Engineering Mechanics. Upon completion of the pending survey of various fields of transportation and the character of instruction and investigation therein, there may be anticipated some rearrangement of certain of the courses above cited and some amplification thereof. Pending such adjustment, the Strathcona memorial fellows will be entitled to pursue investigation in those aspects of transportation in which the university now offers competent guidance and supervision.

Notes on Domestic Railroads

Locomotives

The Missouri Pacific Railroad has placed an order for 10 Mikado and 5 Pacific type locomotives from the American Locomotive Company.

The New York Central Railroad has ordered 10 electric locomotives and one passenger Diesel-Electric locomotive from the American Locomotive Company, and one freight Diesel-Electric locomotive from the McIntosh & Seymour Corporation.

The Baltimore & Ohio Railroad has placed an order for 25 Santa Fe type locomotives from the Lima Locomotive Works.

The Detroit Terminal Railroad has ordered 3 switching locomotives from the Baldwin Locomotive Works.

The Missouri Pacific Railroad has placed orders for 15 eight-

wheel switching locomotives and 10 heavy type Mikado locomotives with the Lima Locomotive Works.

The Union Pacific plans the purchase of 9, 4-10-2 oil-burning locomotives for passenger service.

The Pennsylvania Railroad is inquiring for 100 locomotive tenders of 11,000 gallon capacity.

The Seaboard Air Line Railway has placed an order for 40 Mikado type and 10 Mountain type locomotives with the Baldwin Locomotive Works.

The Wabash Railway has ordered 25 eight-wheel switching locomotives from the Lima Locomotive Works.

The Argentine State Railways have been authorized to purchase 20 locomotives.

The Florida East Coast Railway is inquiring for 50 locomotives including 20 Mikado type, 18 Mountain type and 12 switchers.

The National Railways of Mexico plan the purchase of a number of Consolidated type locomotives.

The Atchison Topeka & Santa Fe Railway has placed an order for 15 Santa Fe type locomotives with the Baldwin Locomotive Works.

The Paulista Railway of Brazil is inquiring for 5 electric locomotives.

The Chicago & Northwestern Railway has ordered one, 60 ton oil-electric locomotive from the American Locomotive Company, the General Electric Company and the Ingersoll-Rand Company.

The Southern Railway is inquiring for 9 locomotives, 5 for its own use and 4 locomotives for the Mobile & Ohio Railroad.

The Atlantic & West Point Railroad has ordered 2 Pacific type locomotives from the Lima Locomotive Works.

The Western Pacific Railway is inquiring for 5 Mountain type locomotives.

The Chile Exploration Company has ordered 6, 70-ton combination electric locomotives and 3, 25-ton pusher locomotives from the Westinghouse Electric & Mfg. Company.

The Kansas City Southern Railway is converting some of its Consolidation locomotives to eight-wheel switchers.

The Oahu Railway & Land Company, Hawaii, has ordered 2 Mikado type locomotives from the American Locomotive Company.

The Andes Copper Mining Company has orderer one Consolidation type locomotive from the Baldwin Locomotive Works.

The Baltimore & Ohio Railroad has ordered 25 Santa Fe type locomotives from the Baldwin Locomotive Works.

Freight Cars

The Reading Company has placed orders for 1,000, 70-ton coal cars; 500 to the Bethlehem Steel Company, 250 each to the Pressed Steel Car Company and the Standard Steel Car Company.

The Louisville & Nashville Railroad has placed an order for 1,000, 50-ton gondola cars.

The Lehigh Valley Railroad has placed orders for 500, 70-ton hopper cars and 100, 70-ton lowside cars with the Bethlehem Steel Company.

The Chicago Rock Island & Pacific Railway is in the market for 2,700 cars.

The Conley Tank Car Company has placed orders for 200, 8,000 gallon steel tank cars with the American Car & Foundry Company.

The North Western Refrigerator Company has placed an order for 200 refrigerator cars with the American Car & Foundry Company.

The Delaware Lackawanna & Western Railroad is inquiring for 500, 50-ton ballast cars and 25 caboose cars.

The American Tar Products Company is in the market for 50, 50-ton cars.

The Lehigh Valley Railroad has placed an order for 500 single sheathed automobile cars with the American Car & Foundry Company.

The Florida East Coast Railway is in the market for 50 eight-wheel caboose cars.

The Chicago & Northwestern Railroad is inquiring for 450 freight cars underframes and 105-65 ton ore cars.

The Baltimore & Ohio Railroad has placed an order for 2,000 cars as follows: 1,000 hopper cars with the Standard Steel Car Company, and 1,000 box cars with the Bethlehem Steel Company.

The Chicago Burlington & Quincy Railroad is inquiring for 1,000 single sheathed box cars.

The Northern Pacific Railway is inquiring for 400 freight car underframes.

The New York Central Railroad has placed orders for 1,550 cars as follows: 500 automobile box cars from the Standard Steel Car Company, 500 hopper cars, from the Pressed Steel Car Company, and 550 hopper cars from the Ralston Steel Car Company.

The Missouri Pacific Railroad is inquiring for 50, 70-ton all steel gondola cars.

The North American Car Company is inquiring for 400, 40-ton tank cars.

The Pittsburgh & West Virginia Railroad has placed orders for 400 gondola cars and 300 composite gondola cars with the Pressed Steel Car Company.

The Missouri Pacific Railroad is inquiring for 50, 70-ton coal cars for service on the New Orleans Texas & Mexico Railway.

The Mobile & Ohio Railroad is inquiring for 500, 40-ton box cars.

The Rochester & Pittsburgh Coal & Iron Company has ordered 500 mine cars as follows: 250 from the Bethlehem Steel Company, and 250 from the American Car & Foundry Company.

The Chicago & Eastern Illinois Railway is inquiring for 500 70-ton hopper cars.

The International Railways of Central America has ordered 10 tank cars from the Magor Car Company.

The Union Refrigerator Transit Company has placed an order for 400, 40-ton refrigerator cars with the American Car & Foundry Company.

Then Kanotex Refining Company has placed orders for 200 tank cars with the American Car & Foundry Company.

The Pacific Fruit Express Company will be in market for 5,000 refrigerator cars.

The Atchison Topeka & Santa Fe Railway has ordered 2,850 cars as follows: 500 box cars from the General American Car Company, 500 automobile cars and 500 refrigerator cars from the Pullman Car & Mfg. Company, 850 gondola cars and 500 box cars from the American Car & Foundry Company.

The National Tube Company has ordered 50 hopper bodies from the Greenville Car Company.

Passenger Cars

The Delaware Lackawanna & Western Railroad has ordered 35 express cars from the American Car & Foundry Company.

The Atlantic Coast Line Railroad has ordered 30 express cars, 25 coaches, 10 combination passenger and baggage cars, 5 combination baggage and mail cars, and 2 postal cars from the Pullman Manufacturing Corporation.

The Great Northern Railway will convert 24 sleeping cars into day coaches.

The Reading Company has ordered 15 baggage cars from the American Car & Foundry Company.

The Baltimore & Ohio Railroad is inquiring for 70 to 80 passenger cars.

The Chicago & Alton Railroad has ordered Oneida power units for application to motorizing one coach from the Railway Motor Corporation, Chicago, Ill.

The Wabash Railway has ordered 20, 70 ft. steel baggage cars from the American Car & Foundry Company.

The Florida East Coast Railroad is inquiring for 6 dining cars, 15 coaches, and 35 baggage cars.

The St. Louis-San Francisco Railway has ordered Oneida power units for motorizing one coach from the Railway Motor Corporation, Chicago, Ill.

The Norfolk & Western Railroad has placed an order for 43 passenger cars, including 18 coaches, 6 passenger-baggage, 4 baggage-mail and 15 baggage-express.

The New York New Haven & Hartford Railroad has placed an order for 5 gas-electric cars with the J. G. Brill Company, Philadelphia, Pa.

The Chicago & Eastern Illinois Railway is inquiring for 300 general service coaches.

The Atchison Topeka & Santa Fe Railway is inquiring for 9 steel dining cars.

The Florida East Coast Railway is inquiring for 2 steel mail cars.

The Chicago Burlington & Quincy Railroad is inquiring for 25 suburban car underframes.

The Boston Elevated Railroad has ordered 60 subway cars from the Standard Steel Car Company.

The Union Pacific Railroad is inquiring for 15 coaches, 5 horse-baggage, 2 baggage-mail, 10 observation, 10 baggage cars and 5 dining cars.

The New York New Haven & Hartford Railroad has ordered 6 dining cars from the Pullman Car & Manufacturing Company.

The Erie Railroad has ordered 24 coaches from the Standard Steel Car Company.

The Columbus & Greenville Railway has ordered one passenger gasoline motor car and trailer from the J. G. Brill Company, Philadelphia, Pa.

The New York Central Railroad has placed orders for 274 passenger cars, as follows: American Car & Foundry Co., 40 coaches, 25 baggage; Pressed Steel Car Co., 50 coaches, 9 passenger-baggage; Pullman Car & Mfg. Co., 35 coaches, 20 diners; Standard Steel Car Co., 32 baggage-mail cars; Osgood-Bradley Car Co., 25 coaches; Merchants Despatch Transportation Co., 20 milk cars; and, in addition will build 18 miscellaneous cars in its own shops.

Building and Structures

The St. Louis-San Francisco Railway plans rebuilding its machine shops at West Tulsa, Okla., which were recently destroyed by fire.

The Central Vermont Railroad plans the construction of an addition to its shops at New London, Conn.

The New York Central Railroad plans the construction of two automatic power sub-stations at 72nd and 158th street, New York City.

The Lehigh Valley Railroad plans enlarging its enginehouse and shops at Easton, Pa.

The Florida East Coast Railway has placed a contract covering the structural iron work at the shops at St. Augustine, Fla.

The Norfolk & Western Railway plans completing the construction of its enginehouse at Bristol, Va. This building was started a few years ago but never completed.

The Chicago & Northwestern Railway plans the construction of a car wheel shop at Winona, Minn., to cost approximately $35,000.

The Fort Worth & Denver City Railroad plans immediate reconstruction of the coach shops at Childress, Texas, which were recently destroyed by fire.

The New York Central Railroad plans an addition to its locomotive shop at Elkhart, Ind., for use as a testing department. It will cost approximately $65,000.

The Texas & Pacific Railway plans rebuilding its pumping station at Laramie, Texas, which was partially destroyed by fire.

The Missouri-Kansas-Texas Railroad plans the construction of an additional unit to its car shops at Denison, Texas, and has awarded contracts for steel used in building.

The Chesapeake & Ohio Railway has placed a contract for a pumping plant at Stevens, Ky., and the reconstruction of the water treating plant at the same point with the Railroad Water & Coal Handling Company, Chicago, Ill.

The Southern Railway plans the construction of a coach shop and shed at Knoxville, Tenn.

The Atchison Topeka & Santa Fe Railway plans the construction of shops, enginehouse and classification yards at Six Points, Ariz.

The Grand Trunk Western Railroad plans the construction of an enginehouse in Chicago, Ill., to cost approximately $12,000.

The Louisville & Nashville Railroad plans the construction of a pumping station in Leawood yards at Memphis, Tenn., to cost approximately $20,000.

The St. Louis Southwestern Railway plans enlarging and remodeling its railway shops at Pine Bluff, Ark. This will include new building and new machinery installed.

Items of Personal Interest

Michael Branch has been appointed tool supervisor of the Chesapeake & Ohio Railway with headquarters at Huntington, West Va., succeeding **George Stroner**, resigned.

C. S. Christoffer has been appointed general superintendent of the Northern district of the Chicago, Milwaukee & St. Paul Railway with headquarters at Minneapolis, Minn.

Van S. Jodon has been appointed president and general manager of the Bellefonte Central Railroad with headquarters at Bellefonte, Pa., succeeding **F. H. Thomas.**

W. H. Blake, superintendent of the Tampa & Gulf Coast Railroad and the Tampa Northern Railroad has also been appointed superintendent of the West Florida division of the Seaboard Air Line Railroad, with headquarters at Tampa, Fla.

C. P. Van Grundy, formerly engineer of water service of the Baltimore & Ohio Railroad has been appointed engineer of tests with headquarters at Baltimore, Md., succeeding **J. R. Onderdonk**, deceased.

R. D. McKeon has been appointed terminal superintendent of the Pennsylvania Railroad with headquarters at Chicago, Ill., succeeding **W. H. Scriven**, deceased. **C. E. Brinser** has been appointed superintendent of the Elmira division with headquarters at Elmira, N. Y., succeeding **R. D. McKeon.**

J. E. Hogan has been appointed assistant division engineer of the Hinton division of the Chesapeake & Ohio Railroad with headquarters at Hinton, West Va., succeeding **W. H. Hanchett.**

W. L. Leighton has been appointed supervisor of passenger locomotive operation on the Seaboard Air Line Railway with headquarters at Tampa, Fla. **J. C. Trigg** has been appointed road foreman of engines with headquarters at Tampa, Fla.

H. E. Shriner has been appointed roundhouse foreman of the Union Pacific Railroad with headquarters at Hastings, Nebr. **H. H. Smoot** has been made district foreman with headquarters at Leavenworth, Kans., and **L. G. Fenn** has been appointed district foreman with headquarters at Marysville, Kans.

H. M. Cooper has been appointed foreman of the Union Pacific shops at Los Angeles, Calif., succeeding **G. R. Godrey**, transferred.

H. O. Kaigler has been appointed division engineer of the newly formed West Florida division of the Seaboard Air Line Railway, and will also serve in the same capacity for the Tampa & Gulf Coast Railroad and the Tampa Northern Railroad.

J. M. Plaskitt has been appointed roundhouse foreman of the Southern Railway with headquarters at Birmingham, Ala. **G. R. Fields** has been appointed assistant roundhouse foreman, succeeding **C. M. Stone**, transferred.

C. E. Westbrook has been appointed roundhouse foreman of the Southern Railway with headquarters at Macon, Ga., succeeding **F. E. Rhime**, resigned. **J. D. Watson** has been appointed foreman of car inspectors, and **C. W. Wolfe** night foreman, with headquarters at Birmingham, Ala.

H. Y. Harris has been appointed master mechanic of the Seaboard Air Line Railway with headquarters at Tampa, Fla. **R. R. Harris** is appointed road foreman of engines with headquarters at the same point. **H. M. Agin** has been appointed road foreman of engines with headquarters at Waldo, Fla.

C. H. Buford has been appointed assistant general manager of the Chicago, Milwaukee & St. Paul Railway with headquarters at Chicago, Ill.

L. F. Muncey has been appointed superintendent of transportation of the British Columbia division of the Canadian National Railways with headquarters at Vancouver, B. C.

T. J. Quigley has been appointed superintendent of the Illinois division of the Illinois Central Railroad with headquarters at Champaign, Ill., succeeding **F. R. Mays,** who has been appointed general superintendent of the Yazoo & Mississippi Valley Railroad. **E. L. McLaurine** has been appointed superintendent of the Louisiana division of the Illinois Central R. R., with headquarters at McComb, Miss.

F. R. Mays has been appointed general superintendent of the Yazoo & Mississippi Valley Railroad with headquarters at Memphis, Tenn., succeeding **A. H. Egan**, resigned.

A. B. Ford, general master mechanic of the Central district of the Great Northern Railway with headquarters at Great Falls, Mont., has been transferred to the Lake and Eastern districts, with headquarters at Duluth, Minn., succeeding **T. E. Cannon**, who has retired.

C. E. McCarty has been appointed inspector of transportation of the Kansas City Southern Railway with headquarters at Kansas City, Mo., succeeding **C. H. Wright**, who has been promoted.

H. E. Patterson has been appointed superintendent of the Buffalo and Rochester division of the Buffalo, Rochester & Pittsburgh Railway with headquarters at Rochester, N. Y., succeeding **M. G. McInerney.**

A. A. Johnson, supervisor of track of the New York Central Railroad with headquarters at West Albany, N. Y., has resigned to become track engineer of the Delaware, Lackawanna & Western Railroad with headquarters at Hoboken, N. J., succeeding **C. E. Gosline,** deceased.

A. L. Bergfeld has been appointed superintendent of transportation of the Great Northern Railway with headquarters at St. Paul, Minn., a newly created position.

Lloyd Crocker has been appointed superintendent of the Atlantic Coast Line Railway with headquarters at Wilmington, N. C.

F. L. Brower has been appointed assistant roundhouse foreman of the Southern Railway with headquarters at Birmingham, Ala., succeeding **R. G. Fields,** promoted.

O. P. Bartlett has been appointed assistant to the vice-president of the Southern Pacific Company, with headquarters at Chicago, Ill.

H. J. McCracken has been appointed master mechanic of the Stockton division of the Southern Pacific Company with headquarters at Tracy, Calif. Mr. McCracken was formerly assistant master mechanic of the Western division with headquarters at West Oakland, Calif.

C. M. Dukes, assistant to the general manager of the Chicago, Milwaukee & St. Paul Railway, has been appointed assistant to the chief operating officer, with the same headquarters as before.

Supply Trade Notes

J. N. Walker has been appointed general sales manager of the **Oxweld Acetylene Company,** New York; **L. D. Burnett** has been appointed eastern department sales manager to succeed Mr. Walker, and **Z. T. Davis, Jr.,** is now assistant sales manager, eastern department.

R. R. Cuthbertson, formerly manager of the Chicago office

of Manning, Maxwell & Moore, Inc., has been appointed representative of the **Stocker-Rumley-Wachs Company**, Chicago, Ill.

R. C. Chacey has been appointed sales representative in charge of sales of the **American Creosoting Company**, with headquarters at 350 Madison Avenue, New York.

The Independent Pneumatic Tool Company, Chicago, Ill., has opened a branch sales office and service station at 1103 Genesee building, Buffalo, N. Y., and has appointed **Joseph P. Fletcher**, manager.

Mudge & Company, Chicago, Ill., has been appointed western representative of the **Graham White Sander Corporation**, Roanoke, Va.

J. H. Ainsworth, railroad representative of the **A. M. Byers Company**, Pittsburgh, Pa., has been appointed director of railroad sales with headquarters at Pittsburgh.

T. D. Owler has been appointed Chicago railway sales representative of the **Heywood-Wakefield Company**, Wakefield, Mass., succeeding **Edward Buker**, who has resigned to enter into business of his own.

W. J. Nugent, vice-president and general manager of the **Nugent Steel Castings Company**, has been elected president of the company and **Prentiss Coonley** has been elected vice-president.

C. W. Damberg, formerly resident inspector of the New York, New Haven & Hartford Railroad at New York has been appointed railroad representative of the **A. M. Byers Company**, with headquarters at New York.

The Yale & Towne Manufacturing Company has bought the **Miller Lock Company**, of Philadelphia, Pa., and it is to be operated in the future as the **Miller Lock Works of the Yale & Towne Manufacturing Co.**

Henry C. Houck, assistant general merchandise manager of the **General Electric Company**, Schenectady, N. Y., has been appointed manager of the merchandise department at the Bridgeport Works.

O. D. Cleveland has organized the **Cleveland Equipment Company**, Houston, Texas, and will handle cars, locomotives and a general line of railway supplies.

Ray A. Sossong, manager of gas plants, **Air Reduction Sales Company**, New York, was elected president of the **International Acetylene Association** at the recent annual convention in Chicago.

The Railway Safety Brake Lock Corporation, Tacoma, Wash., has been incorporated to produce locks for railway cars.

The Standard Steel Car Company has bought the plant of the **Siems-Stembel Company** at Minneapolis, which has been repairing about 4,000 cars a year for the northwestern railroads and where new refrigerator cars were also built.

The Chicago Steel and Wire Company has opened a branch office in Cleveland, Ohio. It is in charge of **R. R. Applegate**, who had conducted numerous welding tests for the United States Navy and for a time was connected with the **Rail Welding and Bonding Company** as an engineer. Mr. Applegate's office is Room 305, Euclid 61st Building, Cleveland, Ohio. Arrangements have also been made for a warehouse stock of Weldite rods in Cleveland.

H. A. Watkins has been appointed metropolitan district sales manager for the **Bridgeport Brass Company** with office in the Pershing Square Building, New York.

E. G. Jones has been appointed general superintendent of the **Inland Steel Company** with headquarters at Milwaukee, Wisc.

Obituary

Howard Elliott, editor of the Union Pacific Magazine, with headquarters at Omaha, Neb., died at Los Angeles, Calif., on January 1, after a long illness. He was born in 1883 at Indianapolis, Ind., and attended the law school of the University of California. He entered railway service of the Illinois Car Service Association, later being appointed secretary to the general manager and then inspector of transportation of the Los Angeles & Salt Lake Railroad. Mr. Elliott was appointed executive assistant of the American Sugar Refining Company in November, 1917. He was appointed editor of the Union Pacific Magazine at the time of its inception in November, 1921, continuing in that position until his death.

William H. Beardsley, president of the Florida East Coast Railway, died on December 13, at his home in New York after a short illness. He was 73 years of age. Mr. Beardsely was born in 1852 at Cleveland, Ohio, and was educated in the public schools of that city. He entered railway service in 1881 as a stenographer with the Richmond & Danville Railroad at New York, and in January, 1882, became private secretary to H. M. Flagler, builder of the Florida East Coast Railway. From 1889 to 1895 he was assistant to Mr. Flagler, at that time president of the Jacksonville, St. Augustine & Indian River Railway. Mr. Beardsley was treasurer and vice president of the Florida East Coast Railway from 1910 to 1914. On March 17, 1914, he became president of the road.

Frank A. Merrill, chief engineer of the Boston & Maine Railroad died on December 21, at his home in Lynn, Mass., after a long illness. He was born on September 1, 1857 and graduated from the Chandler Scientific Department of the Dartmouth College in 1878. He entered railway service in 1884 as a rodman on the Boston, Concord & Montreal Railroad and until 1895 he was chief engineer on the Concord & Montreal Railroad, now a part of the Boston & Maine Railroad, and later on he became assistant chief engineer. He became engineer maintenance of way which he held until the latter part of 1924, when he became chief engineer.

William Brownlee Albright, well known in the railroad world, and one of the directors of The Sherwin-Williams Co., of Cleveland, Ohio, died suddenly on the evening of December 25th, while visiting in Cleveland.

Mr. Albright has been well-known throughout our industry for many years. He has been closely associated in both a business and personal way with most of the railroad officials in New York City, and has numbered among his friends many of the most prominent men in the United States.

Mr. Albright was born in Philadelphia, Pa., on July 17th, 1855, and started his connection with The Sherwin-Williams Co., in January of 1885. For forty years he has been active in the company, of which he has been a director since 1894. To the end he kept up his very keen interest in all the activities of the company, and was a warm personal friend to all the men in the concern.

For the past twenty-five years he has made his home in New York, where he was a member of the Athletic Club, The Machinery Club, and the Englewood Golf & Country Club.

New Publications

Books, Bulletins, Catalogues, etc.

Development of the Locomotive. The Central Steel Co., Massillon, Ohio. 64 pages, 8½ in. by 11 in. Cloth.

Much has been said, written and published regarding the history and development of the locomotive but it is doubtful whether anything heretofore put forth, has appeared in so attractive a form or contained so much in so condensed a space as this volume just issued by the Central Steel Co.

In consists of fifty-three illustrations of the examples of as many types of locomotives with a brief account of the first of the kind to be built. The illustrations show the locomotive in an appropriate setting. The first of the series is the diminutive Cugnot locomotive built in 1769 and it is shown as moving across the square of Notre Dame in Paris, with the cathedral in the background and a soldier marching beside the machine as a guard, while the on-looking crowd is dressed in the costumes of the day.

Then follow the locomotives of Murdock, and Trevethick, the Puffing Billy locomotive and the Rocket by which the final seal was set on the practicability of railroad operation by means of the locomotive.

From this on the illustrations are confined to locomotives of American design that were built for American railroads. Fourteen examples are shown, which belong to that period of trial and error extending from 1830 to 1840, during which builders were experimenting without any precedent and trying to evolve the best from a series that seem grotesque to the modern eye, but which finally resulted in the American type, which in spite of many rival designs, at last became the standard design for freight and passenger service. From 1840 on the odd designs are fewer and by 1860 we find the development taking on distinctly a tendency to increased weight and power. During this decade the mogul, the consolidation and decapod appear, and then, in the nineties the trailing truck comes to the front and, with it, the great increase in weight and power that has culminated in the mountain, Santa Fe mallet and Southern Pacific types. There is also included the Horatio Allen, the three-cylinder, and notable examples of heavy electric locomotives, the series ending with the latest development, the Lima A-1 of the 2-8-4 type.

There then follow three illustrations of interiors of the works of the Central Steel Co., with a brief account of the work of producing the high grade steel demanded by present-day conditions.

The foreword was written by Mr. J. Snowden Bell, in

which is given a brief and interesting survey of the field that has been covered in the last century of progress and development.

Aside from the immediate object of the book which is expressed by the title there is a secondary plot, as it were, in the foregrounds of the pictures which give an interesting study of the costumes of the day when the first of the several types appeared, and which, with the representations of the locomotives reflect the great skill of the artist, Mr. Irvin Myers, by whom they were drawn.

The volume is beautifully printed and the pages have a cream colored center on which the engravings and text are impressed. The book has, therefore, three great merits; it is fair to look upon, it has great artistic merit and it is a notable and valuable contribution to the subject upon which it treats.

Analysis of Railroad Operations, by Joseph L. White, formerly assistant comptroller, U. S. R. A., contains 381 pages, leatherette binding and published by the Simmons-Boardman Publishing Company, New York.

This is a valuable addition to railway accounting and operating literature.

In these days of increasing demands on the part of the public, the railway patron and numerous legislative and regulating bodies, all those who have to do with railway operation, finance, or statistics, are constantly in need of a standard up-to-date text book or guide, with examples and definite rulings or interpretations whereby intelligent and correct analysis of all phases of railway operations may be made.

In a condensed review of the field covered by this book the author's foreword presents a picture indicative of its wide scope and great value.

"With the increasing magnitude of railroad operations, the railroad executives are forced to depend more and more on the accounts and statistics for an accurate picture of the various activities on the lines under their jurisdiction. Happily the standardization of the accounts and statistics on the railroads of the United States under the general supervision of the Interstate Commerce Commission has progressed to such an extent that the operating results on a railroad can be analyzed with reasonable accuracy and completeness both by comparison with previous performances on that railroad and by comparison with the performances on other railroads operating under similar conditions.

"In making these comparisons, the analyst as a rule is safe in assuming that the accounting has followed strictly the rules laid down by the Interstate Commerce Commission in the various accounting classifications which it has issued. Familiarity with these classifications makes it possible for the railroad man or student of railroad operations to interpret the accounting and statistical statements prepared by the accounting department and analyze for himself the operating results on the railroad even though he is not familiar with the technical details of railway accounting."

This book deals primarily with the interpretation rather than with the preparation of the accounts and statistics. A study of its pages will not only make the vast fund of information contained in the accounting records and statistics more available to railroad men and other students of railroad operations without accountant training, but will also give railroad accountants a clearer idea of the operating man's point of view and the use that can be made of the figures prepared by the accounting department.

Railway and Locomotive Historical Society Bulletin No. 10. This Association has recently issued another of its highly interesting bulletins that contain so much of real value in the way of history of early locomotives and other railway historical information.

The latest issue contains articles on the Early Baltimore & Ohio Engines and Models; The locomotives of the Long Island Railroad by Inglis Stuart; A History of the Norris Locomotive Works by the late C. H. Carruthers, and some notes on the Norris engines constructed for the Birmingham & Gloucester Railway by G. W. Bishop.

As is customary in all of the bulletins issued by the Railway and Locomotive Historical Society, the volume contains a number of illustrations of early locomotives.

Those interested in matters dealing with railway and locomotive history can obtain copies of the bulletins of the Association by addressing the editor, Mr. Charles E. Fisher, 6 Orkney Road, Brookline, Mass.

"Patents, Law and Practice" has been issued by Richards & Geier, patent and trade-mark attorneys, 277 Broadway, New York, and is available to manufacturers and those generally interested in the subject of inventions and their proper and adequate protection. Both United States and foreign patents are covered, information being given as to who may obtain patents, what may be patented, how to apply for a patent, the procedure followed in the patent office, interferences, reissues, appeals, infringements, etc. The charges for various services in connection with the preparation of the patent are given in schedule form.

General Electric Catalogue: General Electric Catalogue 6001B, superseding all previous catalogues issued by the company, with the exception of those dealing with railway, mine and industrial supplies and merchandise products, is being distributed. The complete catalogue is issued every two years.

The book is two inches thick, and contains more than 1100 8 x 10½-inch pages. The illustrations total more than 3200.

The catalogue is thumb-indexed into 16 sections as follows: Generation, wire and cable, distribution transformers, arresters, voltage regulators, switchboards and accessories, meters and instruments, motors, motor applications, industrial control, railway lighting, industrial heating, miscellaneous, and indexes. In the indexes, products are classified both by subjects and by catalogue numbers.

Railway and Locomotive Engineering

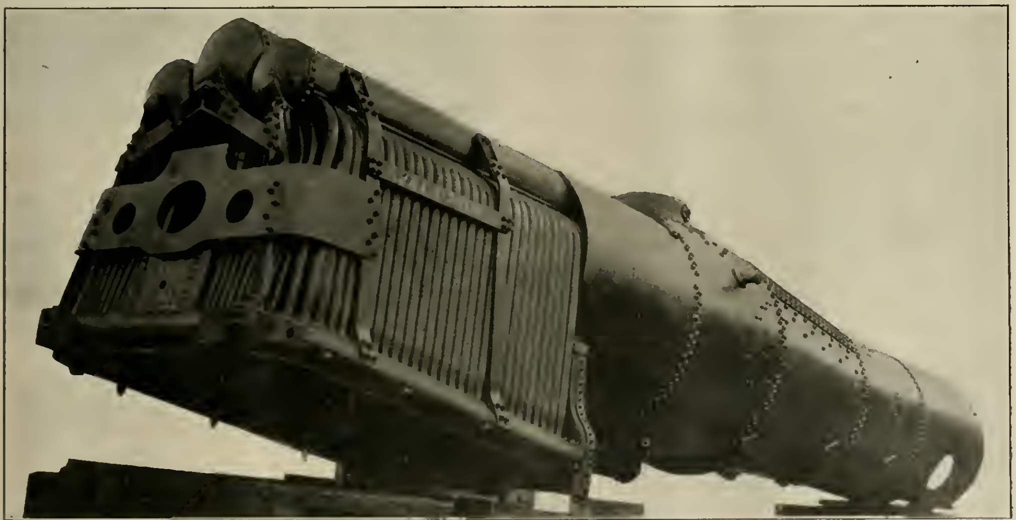
A Practical Journal of Motive Power, Rolling Stock and Appliances

Vol. XXXIX — 136 Liberty Street, New York, February, 1926 — No. 2

The McClellon Water Tube Boiler

A Successful Development of the Water-Tube Boiler on the New York, New Haven & Hartford Railroad

For a number of years the New York, New Haven & Hartford Railroad have had a locomotive in experimental service, that was equipped with the McClellon Water-tube boiler. As happens in such cases the original design developed some weaknesses in the details of its construction; but, at the same time, showed that its fundamental principles were mechanically sound, and that with a modification of the details that were giving trouble, the boiler would probably give satisfactory service. These changes were made and embodied in a new boiler that was built and installed in a mountain type (4-8-2) locomotive. This engine was put into regular freight service and subjected to extensive road tests in comparison with a similar engine having a radially stayed boiler. The results of this service and the tests were so satisfactory and so conclusively demonstrated the advantage of the McClellon boiler that, when ten new engines were recently purchased for the road, there was no question or discussion as to the type of boiler to be used but the McClellon water tube boiler was ordered to be placed in each of them.



The McClellon Water Tube Boiler Now in Service on the New York, New Haven & Hartford Railroad

The McClellon boiler was originally designed by the late James M. McClellon of Everett, Mass., who died just as the boiler had demonstrated its efficiency, and it is the property of the McClellon Locomotive Boiler Co. of Boston, Mass. As originally designed and modified in detail by Mr. W. L. Bean, superintendent of motive power of the New Haven road, it consists of a water tube firebox in combination with the shell and nest of fire tubes as used in the ordinary locomotive boiler.

Viewed from the standpoint of the present design, it is of a very simple construction and one that appears to be well adapted to meet or yield to the stresses that may be set up by the varying temperatures to which the different parts may be subjected.

The details of the construction are set forth in the accompanying engravings.

The side and rear elevations (Figs. 1 and 2) show that the sides and back end of the firebox are formed of water tubes, as are also the sides of the combustion chamber. What corresponds to the roof and crownsheets, is formed of three drums, extending longitudinally over the whole length of the firebox and the combustion chamber and attached, at the front end, to the back tube-sheet.

distributor tube of the Duplex stoker. This will, however, not be necessary in the case of the ten locomotives now under order as they will be equipped with the Standard stoker.

The firedoor opening is of a combination water leg and water tube construction. The space beneath the door at *A* is built up of three pieces. There is a single sheet *B*

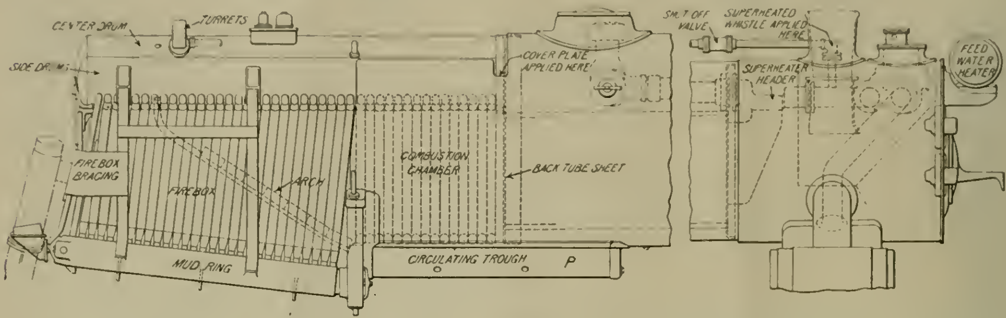


Fig. 1—Side Elevation of McClellon Water Tube Boiler

As shown by the half rear elevation these drums are set in contact with each other and are flattened so that they may be rivetted together and prevented from separating, under the influence of the heat, and thus forming an opening between them through which the gases and products of combustion might escape.

The flattened sides at the points of contact converge downwardly so that the central drum fits between those at the sides like a keystone, thus providing a very strong assembly. The arrangement is also such that the level of water in the crown may be lowered to a considerable degree without exposing any surface uncooled by water to the heat of the fire.

The tubes in the sides of the firebox and combustion chamber are 4-in. in diameter and ¼ in. thick, while those forming the back head are of 2 in. diameter and 3/16 in. thick. Those forming the sides are swaged down to a diameter of 3 in. at the ends and are rolled and beaded in the drums and flared in the mud ring. These and the arch tubes enter the drums on a line with a radius and are bent at the upper end for this purpose.

The section of the mud ring is flattened on the inside and outside where the tubes enter, and on the outside, where the plugs enter. There is a plug opposite each tube. These tubes are set side by side with just sufficient clearance to provide for expansion and contraction and are covered, on the outside by a lagging to which reference will be made later. All of these plugs are not washout plugs but are so-called construction plugs.

Instead of being arranged close together like the side tubes, those forming the back head are spaced about 1 in. apart. This facilitates their connection to the drums at the top, where they are staggered, though they are kept in line where they enter the mud ring. On locomotive No. 3500, from whose boiler the illustrations here given are taken, two tubes half way between the firedoor and the side are bent, as shown, so as to admit the

that is bent into the shape of an inverted U which is flanged and riveted to the mud ring as shown. This portion is stayed in the same manner as the ordinary firebox. The open ends of this U are closed by sheets *C* bent and

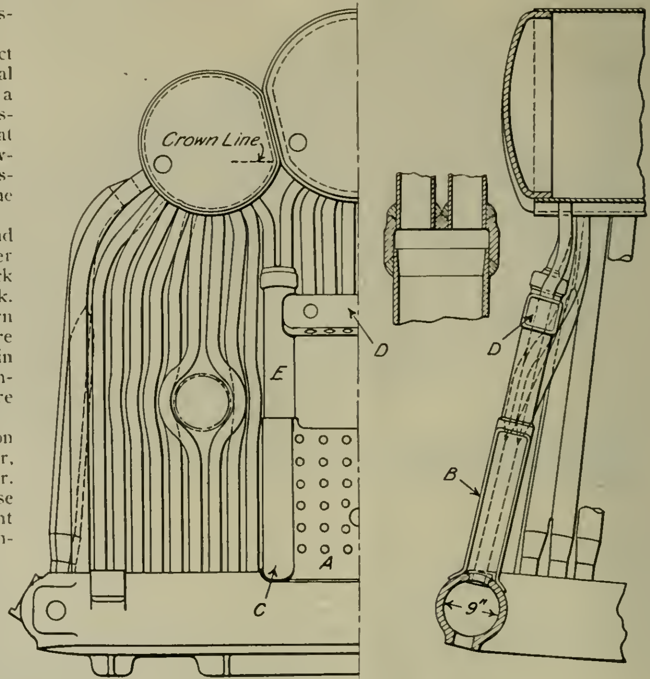
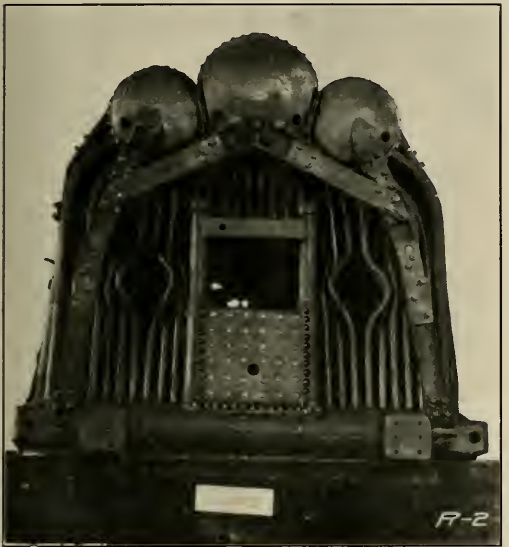


Fig. 2—Back End of McClellon Firebox

riveted in place. The sides of the door opening are formed by sheets bent to a U shape and riveted vertically to the main sheet *B* and with it forming a circular opening at the top into which the tube *E* is welded.

The top of the opening is formed by the tube *D* that is flattened on four sides. Six rows of tubes enter this at the top and are fastened in the same way as are their mates into the mud ring. It is welded into the side of the vertical tubes *E* thus completing the door opening.

The tubes *E* are carried above it and are capped as shown in the enlarged section. The cap is held in place

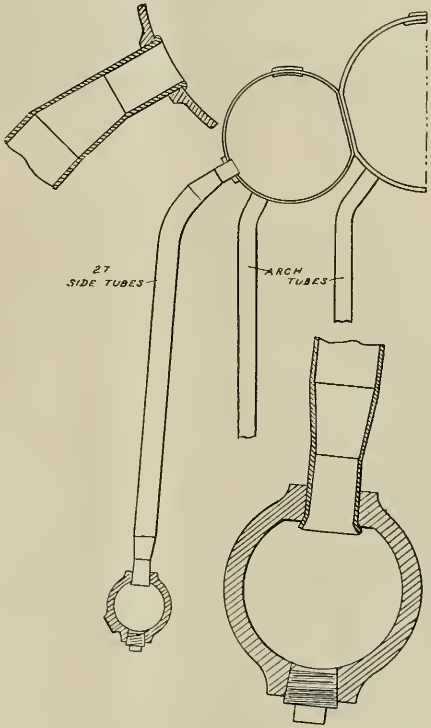


Back View of McClellon Water Tube Boiler

by a steel casting that is welded on and into the top of it the fourth and fifth tubes from the center are welded.

One of the troubles with the original construction was the lack of provision for any column action that could be carried independently of the tubes to sustain the stresses set up between the mud ring and the drums.

The length of the drums is 15 ft. 4½ in. and they are wholly back of the back tube sheet. In order to provide in part for the support of the drums and to bind the firebox structure firmly to the barrel of the boiler the third course of the latter is continued rear-wardly of the rear tube sheet and cut away on the top to receive the forward ends of the drums. The sides of this segmental extension of the third course are riveted to the side drums. The space within this extension of the third course receives and supports the combustion chamber tubes to be hereafter described. By this arrangement the crown is supported by a long joint with the barrel and the connection of the forward ends of the drums is spaced from the connection of the forward ends of the mud ring to the throat so that there is no point of weakness in the length of the boiler as would be found if these connections were made at the same point. In order to relieve the side wall tubes of any structural loads other than those occasioned by reason of their containing hot water under pressure, the drums are supported from the mud ring by a system of struts at the firebox portion. The drums and mud ring are fastened together by the braces *F* shown in the engraving (Fig. 3) of the firebox bracing. These struts or braces are channels that are bolted to the drums and mud ring and tied together by a horizontal piece *G*. This arrangement of the bracing which is free from triangulation, permits of a comparatively free longitudinal movement of the drums relatively to the mud ring, without putting an undue stress on any part, at the same time the firebox tubes are relieved of all structural loads, other than those occasioned by reason of their containing hot water under pressure. Shocks incident to locomotive service are transmitted through this bracing construction and kept away from the tubes to a noticeable degree of success as evi-



Side Tubes, Arch Tubes and Section of Mud Ring of McClellon Water Tube Boiler

denced by continuously tight water tubes, even under severe and unusual operating conditions.

At the back there is a brace *H* also bolted to the mud ring and to a casting *I* that is fastened to the back head of the outer drum. The central drum is carried by the diagonal brace *K* bolted to the brace *H* and to the casting *L*. These bracing members are held to their connections by means of fitted bolts, and the joints between the braces and the casting are fitted with shoulders and lips to relieve the bolts of any shearing and to prevent working. Extending from the rear brace *F* on each side and around the back of the firebox there is a plate *M*, also bolted to the braces *H* which not only forms a part of the firebox bracing but also carries all of the heavy fittings and appliances that are usually carried on the back head.

At the front end of the firebox there is a throat sheet as shown in Fig. 4. This is similar to the throat sheet of an ordinary boiler and is formed of two sheets flanged and riveted together as shown in the section on 1-1. The back plate of the throat sheet is flanged to receive the mud ring as shown on the section 2-2. The front sheet is flanged inwardly at the same place and is fitted with an ordinary manhole plate held by a yoke. From the upper corner of the throat sheet a vent pipe *N* leads up to a

point above the water line in the central drum. This is to permit the escape of any steam that may be generated in the throat.

Welded to the bottom of the dry sheet just ahead of the throat sheet at 3, is the lower end of the back tube *O* of the combustion chamber. The upper end enters the side drum just as the side tubes of the firebox do; and this applies to all of the tubes forming the combustion chamber.

We have already referred to the extension of the boiler shell back of the back tube sheet and overlapping the forward portions of the crown drums. This extension houses the water tubes in the combustion chamber and supports the circulating trough *P*. This trough is a sheet bent to

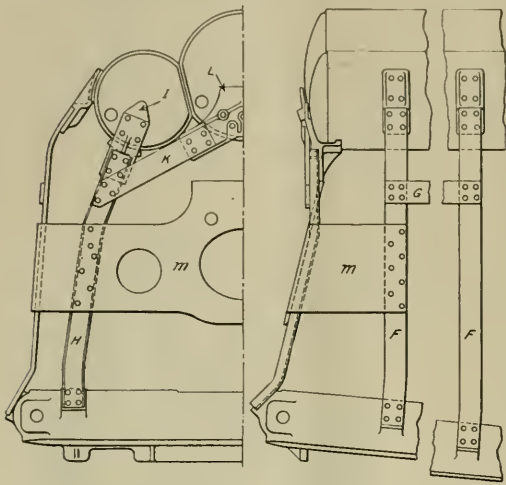


Fig. 3—Firebox Bracing of the McClellon Water Tube Boiler

a U section and riveted to the bottom of the shell. It has a total length of 8 ft. 8⅜ in. and extends from the throat in which it is riveted and into which it opens, forward to the boiler shell and about 44 in. ahead of the back tube sheet. This trough is about 12½ in. deep and of the same width. Along the line of its attachment to the extension of the shell the latter is cut with a series of holes through which the combustion chamber tubes communicate with the circulating trough as shown in the engraving (Fig. 5) of the latter.

This dry sheet is a very important part of the construction, in that it gives the necessary strength for connecting the firebox portion of the boiler to the barrel section. It serves as an envelope for the combustion chamber tubes, is double rivetted to the outside drums throughout the length of the combustion chamber and prevents any hinge action between the barrel and the firebox.

There are fifteen combustion chamber tubes on each side which are bent to the contour of the extension of the third course with suitable clearance for expansion and contraction and they line this rearward extension. They are 4 in. in outer diameter, swaged to 3 in. at their top ends and enter their crown drums in exactly the same manner as the side tubes and at the same point.

The bottom of the tube is flattened and curved to fit the dry sheet and is fastened to it by a nipple 4, which is applied from the bottom and is rolled in, and beaded and welded on the under side. The method is to apply the circulating trough and then apply the fifteen tubes on each side that form the combustion chamber. The circulating nipples, 4, are then beaded and welded through the open ends of the tubes, after which the tube ends are closed by the plates 5, which are welded in place, and then the space block 6, by which the nipples are relieved of all shearing action is welded in between the ends of the tubes to the dry sheet.

The sides and bottom of the trough are held by staybolts

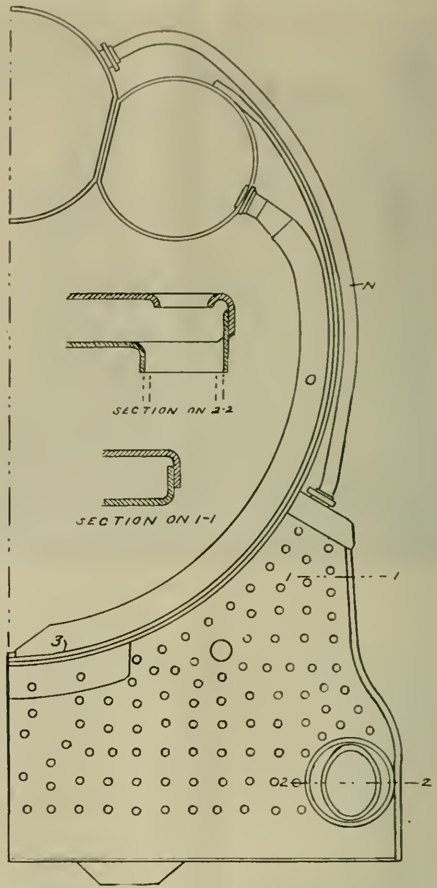


Fig. 4—Half Cross-Section of McClellon Water Tube Boiler Showing Combustion Chamber and Throat Sheet

after the manner of firebox staying and the front head is stayed to the throat sheet by through stays as shown.

Just in front of the back tubesheet a hole 13 in. in diameter is cut in the bottom of the shell through which the water enters the circulating trough to flow back to the throat and mud ring.

The making of the back tubesheet involves a careful piece of flanging. It is flanged to the front all of the way around to take the third course of the boiler shell, and then it is flanged back to receive the three drums which are riveted and welded in place. It will be noticed that the flanging to the front and back is in a straight line, where the flanges for the drum reach the outer circumference.

In the boiler shell there are 201 tubes of 2¼ in. diameterand 40 superheater flues of 5½ in. in diameter, all having a length of 20 ft. 6 in.

The lagging on the outside of the firebox consists first of a jacket of ½ in. mesh No. 18 gauge steel crete expanded wire 9, that is bent and fitted to conform to the contour of the tubes. Then the unevenness is filled in and the whole made smooth with a layer of cement 10. This is covered with asbestos paper 11, outside of which there is a protection plate 12. Then there is an insulating lagging of thermo-felt 13, with the whole covered by a sheet iron jacket 14.

The lagging is made up in sections with each panel self contained in order to permit the removal of lagging in sections without the necessity of wholesale stripping for access to tubes and other parts. The protection plate is applied after the tubes have been covered with an asbestos cement. Next to the protection plate is thermo-felt lagging and finally ordinary jacket iron. Each panel consists of its own section of protection plate, thermo-felt and jacket iron and is removable and replaceable through the use of studs and bolts which are applied to the bracing and also to small angle irons so arranged s to sectionlize the sides and back head of the fire box.

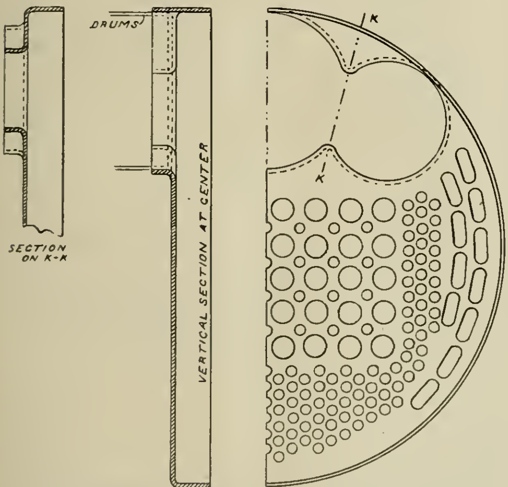


Fig. 6—Back Tubesheet of McClellon Water Tube Boiler

While no investigation has, thus far, been made as to the character and direction of the circulation in this boiler, it seems probable that the water after entering the shell at the injector check drops to the bottom and moves back until it reaches the large hole that opens into the circulating trough; then, that it drops back and moves with considerable rapidity, losing speed as it moves back through the trough and the mud ring, because of the continual decrease in the quantity of water passed because of the upward currents taken from it by the tubes of the combustion chamber and firebox. That this circulation is quite rapid is evidenced by the fact that all of these parts are found, after a long service, to be quite free from mud and scale.

That this method of circulation in the boiler is the one that obtains is confirmed by observations on the bare boiler when fired during construction without any lagging or insulation whatever, when a very uniform heating and warming of the entire boiler from front end to back head occurred without the usual unequal warming and heating normally experienced in the radial stayed construction.

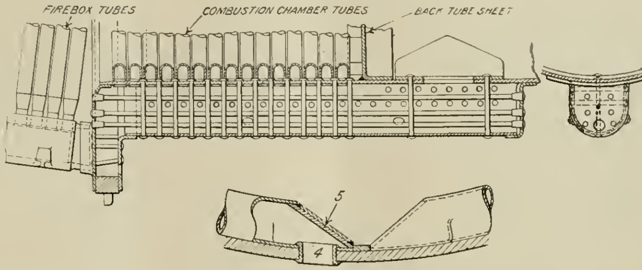


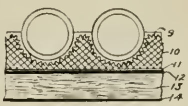
Fig. 5—Circulating Trough of McClellon Locomotive Boiler

In addition, the time required to fire up the cold boiler is noticeably less and takes approximately only two-thirds of the time experienced with the radial stayed construction.

Most of the mud accumulated is relatively soft and is deposited in the trough section. In other words, the dead corners of the conventional boiler and fire box are absent in the McClellon construction.

The freedom from unequal heating, momentary distortion of the firebox while warming up, more rapid circulation and absence of dead corners that give rise to mud and scale accumulation, all indicate a better type of boiler construction than normally used, a condition that is noticed particularly at washout times. The time required to wash one of these boilers is only about one-half or two-thirds of the time required for the ordinary boiler. Stresses due to unequal temperature conditions are greatly reduced as indicated by considerably less maintenance on the fire box and combustion chamber portion of the boiler.

There is greater potential capacity in this type boiler when the locomotive is running with leaky flues or superheater units. It is possible, but of course not practicable, to operate these boilers with a far greater number of flues and units leaking before low steam conditions are experienced than is the case in the ordinary locomotive boiler.



Jacket and Lagging for Firebox of McClellon Water Tube Boiler

Washout plugs are liberally applied, as indicated in Figs. 1 and 2. It will be noticed that the arrangement of the mud ring, with its corners extended for washout plugs, permits positive and direct flushing of the mud ring area from the back end down towards the throat, where removal of mud and foreign matter is very readily made through the use of the hand hole plates in the front throat sheet. Plugs are, of course, applied over the arch tubes in the drums and opposite them in the throat, as well as additional plugs in the back head, throat and circulating trough.

It is evident that the greater the rapidity of this circulation the greater will be the equalization between the temperatures of the drums and the mud ring, and consequently the less will be the bending stresses put upon the tubes of the firebox and combustion chamber. As no trouble is now experienced with any of these parts, it is evident that the stresses due to unequal temperatures are greatly reduced

and that the strength of the boiler is quite sufficient to resist those that do exist.

The principal dimensions of the boiler are as follows:

Boiler	Heating Surface, Sq. Ft.	Length	Diam., In.	Gauge or Thick.
Boiler Tubes—201	2,469	20'6"	2¼"	No. 11
Boiler Tubes—40	1,134	20'6"	5½"	No. 9
Total Tubes and Flues	3,603	....	....	.....
Drums—2 Outside—1 Center	81.8	....	....	....
Drums—2 Outside	....	15'8⅜"	23"	½"
Drums—1 Center	....	15'9½"	30¼"	⅝"
Combustion Chamber Tubes—30	115.8	90"	4"	¼"
Firebox Side Tubes—58	171	67"/90"	4"	¼"
Firebox Back Tubes—28	16	14"/63"	2"	3/16"
Firebox Back Section	46.5	....	....	.....
Arch Tubes—4	27	....	3"	No. 7
Total Firebox	458	....	....	.....
Total Boiler and Firebox	4,057	....	....	.....
Superheater Tubes	1,009	19'6½"	1½"	.....
Grate Area			70.8 Sq. Ft.	
Boiler Pressure			250 Lbs.	

There are a few details that were developed in the construction of the boiler that are interesting as showing the means by which some of the structural details were overcome, and which may be applicable in other places.

One of these is the method of closing the throat corners at the narrow points at the right and left. The outside throat sheet is flanged against the dry shell of the combustion chamber and the main section was welded in place and the lap seam was smoothed by scarfing and welding so as to leave the outer edges smooth. A flanged cap was then applied hot and fitted into place and the screw rivets put in. The cap was then welded to the top plate and the dry shell, after which the vent pipe opening was reamed and the studs put in.

As shown in Fig. 1, and already described, the third course of the shell is carried back to the tubesheet to form the dry shell of the combustion chamber and is riveted to the drums along the line where it is cut away at the top.

The drums, it will be remembered, are carried into the flanges formed on the back side of the tube sheet, and this requires that the joints so formed should be accessible for calking. This calking is readily possible except where the dry shell overlaps the tubesheet flanges at the right and left sides where the drums enter them. In order to give access to these places, the dry shell is cut away still more at the points indicated leaving an opening through which the seams can be calked both externally and internally. But, if the opening thus formed were to be left uncovered it would open a free passage from the combustion chamber and permit gases to escape directly to the lagging. In order to prevent this a cover plate *B* is applied over the opening. This cover plate can be easily removed and replaced and thus serves to seal the opening in the dry shell. By removing it any necessary attention may be given to the tubesheet flanges. Three studs 15 are used, as indicated, to hold the cover in place. The latter is fitted to seal the U-shaped opening, and it can be removed by taking off the nuts from the studs.

Some of the other features of the boiller are that there are two independent turrets, one for saturated and one for superheated steam. The turret for saturated steam takes its supply from the center drum in the conventional manner. The superheated turret is supplied through a dry pipe connected to the main steam pipe on the left hand side between the superheater header and the throttle in the smokebox as shown in the boiler (Fig. 1). A shut-off valve is provided near the front end. This superheater turret is mounted on the center drum and has no steam connection other than the one to the header.

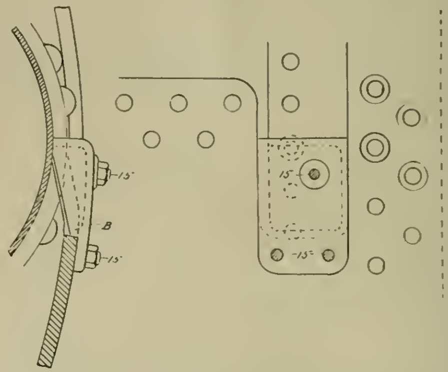
Superheated steam is supplied from the turret to the feed-water heater, the blower, the stoker, the dynamo and the air pump, while saturated steam is supplied from that turret to the steam heating lines, the lubricator, the injector and the drifting valve.

All valves from both of the turrets have extension handles that are carried back to a common bracket and with an individual name plate for each valve.

The water glass and gauge cocks are carried on a water column located on the engineer's side of the cab. For this the top steam connection is taken from a point close to the back end of the center drum and the bottom or water connection is taken from the right hand side drum.

The actual position of the crown, that is the junction of the outside of the sheets of the center and outer drums, is indicated by center punch stamping on the back heads as indicated in the illustration of the back head arrangement (Fig. 2). This eliminates the necessity for careful leveling and firebox measurements to determine the actual location of the crown line with respect to the water glass.

The lowest water gauge is set 3 in. above this crown line with a 3 in. space between each of the other two.



Cover Plate at the Junction of the Third Course and the Dry Shell, McClellon Water Tube Boiler

The locomotive to which the boiler was applied is of the mountain (4-8-2) type having the following general dimensions in addition to those already given in connection with the boiler:

Cylinder diam.	27 in.
Piston stroke	30 in.
Width of firebox	7 ft. 1 in.
Length of firebox	10 ft.
Diameter of 1st Shell course	6 ft. 6⅜ in
Wheel base driver	18 ft. 3 in.
Wheel base total engine	40 ft. 10 in.
Wheel base engine and tender	76 ft. 5½ in.
Weight on drivers	243,500 lbs.
Weight on front truck	59,500 lbs.
Weight on rear truck	57,000 lbs.
Weight on total engine	360,000 lbs.
Weight on total engine and tender	549,000 lbs.
Wheels, diameter driving	60 in.
Wheels, diameter front truck	33 in.
Wheels, diameter rear truck	43 in.
Wheels, diameter tender	33 in.
Total length of engine	53 ft. 5⅞ in.
Total length of engine and tender over couplers	87 ft. 2¾ in.
Maximum curvature	19 degrees
Front truck swing	4½ in.
Trailing truck swing	6¼ in.
Valve gear	Southern
Maximum cut-off	70 per cent
Feedwater heater	Elesco
Coal capacity	16 tons
Water	10,000 gals.
Tractive effort	63,390 lbs.
Factor of adhesion	3.84

Calculated evaporation in lbs. per hour:

Tubes at 8.52 lbs.	21,035 lbs.
Tubes at 9.8 lbs.	11,113 lbs.
Arch tubes at 55 lbs.	1,485 lbs.
Combustion chamber at 55 lbs.	6,369 lbs.
Firebox at 55 lbs.	17,336 lbs.
Total evaporation plus 10 per cent	63,072 lbs.
Steam consumption (3090x19)	58,710 lbs.
Boiler factor	107.2 per cent
Heating surface ÷ grate area	6.47 per cent
Total heating surface ÷ firebox heating surface	8.86 per cent
Total heating surface ÷ superheater heating surface	4.02 per cent
Weight of water in boiler at a height of 2½ gauges	38,440 lbs.

When this locomotive was built as many dimensions and characteristics as possible were kept the same as the conventional 4-8-2 engine so that all tests could be made on a comparable basis as between the McClellon equipped and the standard locomotive, thereby eliminating variables that would tend to influence conclusions. Consequently cylinder and wheel sizes, grate area, heating surface, superheater surface, etc., were all kept at the same values and the changes in the McClellon equipped locomotive were confined to the fire box arrangement, boiler pressure, valve events, and to some extent, weight on drivers. Virtually the same limitation on axle loads held good for the McClellon equipped engine as compared to the standard type.

On leaving the boiler the saturated steam from the steam space in the dome is first passed through a centrifugal dryer in order to remove the moisture and insure that dry steam is going to the superheater, thereby relieving the superheater of performing any evaporative functions.

This dryer is a simple centrifugal separator with fixed vanes that give the steam a whirling motion by which the moisture is thrown out against the side walls of the dryer and then flows down to the bottom and from there back to the water space through the open drain pipe while the dried steam continues on down through the vertical pipe to the dry pipe.

In order to isolate the superheater for inspection or repairs a shut-off valve is provided. This is operated by means of a handle extending out through right side of the shell.

The main valve is fitted with a pilot valve that opens first and closes last, and so controls the flow of steam through the four equalizing ports that a balanced pressure is obtained on each side of the main valve at the time of opening and closing the shut-off valve and thus avoids the necessity of moving the main valve with or against a heavy pressure.

After leaving the dome valve the saturated steam passes through the conventional dry pipe to the superheater as shown in (Fig. 1). The throttle is not located in the dry pipe but between the superheater header and the cylinders, so that the superheater units are filled at all times with steam. From the drypipe the steam enters the superheater header from which it emerges to pass through the throttle and steam pipes to the cylinders.

The throttle is of the conventional design differing only from the common arrangement in the matter of the operating rigging. A rod is run along the boiler from the cab quadrant and is connected to a rocker arm which actuates a rock shaft controlling the regular pilot and main valves.

As will be seen from (Fig. 1) the feed water heater is located on top of the smokebox and is held by a bracket whose feet are bolted to the front casting. That the smokebox may be opened without disturbing the heater, the front is parted on a horizontal line about midway between the center and top of the smokebox. This leaves the upper section permanently in place, while the lower section is mounted upon hinges in the usual manner. By swinging this open access to the interior of the smokebox is obtained.

As already stated this engine (No. 3500) has been subjected to extensive road tests and a comparison made with previous tests made with a New York, New Haven & Hartford Railroad mountain (4-8-2) type engine No. 3324.

For convenience of reference the following general characteristics of the two engines are given:

	Engine 3324	Engine 3500
Type	Mountain	Mountain
Boiler	Firetube	Firetube
Firebox	Radial Stayed	McClellon
Weight on Drivers	230,500	243,500
Total weight, engine and tender	518,800	549,000
Boiler pressure	200	250
Cylinders	27x30	27x30
Maximum cut-off	85%	70%
Diameter of driving wheels	69	69
Tractive effort	53,900	63,390
Factor of adhesion	4.28	3.81

The tests with both engines were conducted over the same divisions, that is from New Haven to Providence, a distance of 113 miles. It will be seen from the accompanying profile that with the exception of a start at each end of about three miles, and the climb from Wood River Junction to the summit a mile east of Slocums going east a distance of 14 miles, and East Greenwich about seven miles to the same point, going west, all of the adverse grades may be considered as momentum grades, as the profile shows a continued succession of favorable and adverse grades very few of which are more than 2 miles long.

While these tests, as conducted on the New York, New Haven & Hartford Railroad may not be comparable with tests conducted on another railroad with the same locomotive, because of a difference in the physical and operating conditions, it is felt that these two series of tests are comparable because of their being conducted in the same manner over the same piece of track, and under the same operating conditions. Particular pains were taken to have all readings made at the same predetermined locations throughout both series and the same quality of coal was used, it having an average calorific value of 13,500 B.T.U. per pound of dry coal. All coal used was weighed on scales placed on the tender.

Before presenting the comparison of the test attention is directed to the table of dimensions given above. The cylinders had the same diameter and piston stroke but the 3500 had the advantage of 50 pounds in steam pressure with a consequent higher tractive effort by about 17.6 per cent, but at the expense of a lowered factor of adhesion. Contrary to general belief, the lower factor of adhesion is not productive of any special care in handling, due to the smoother piston effort resulting from relatively shorter cut-offs.

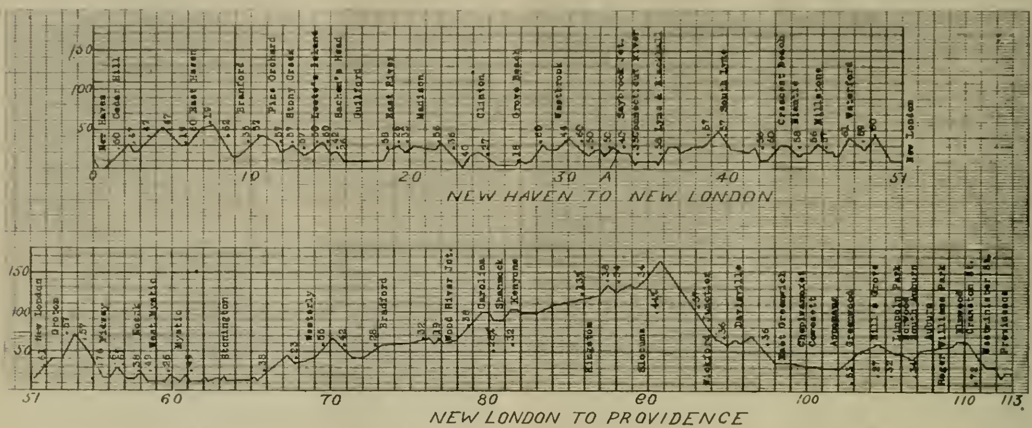
This table shows a general superiority of the No. 3500 as compared with the No. 3324, and much of the data and difference is due to the engine for which the boiler can claim no share and which thus falls outside the field of this particular discussion, which pertains chiefly to a comparison of the boiler performances.

Aside from the steam chest temperatures and the degrees of superheat, in which the No. 3500 is in the lead by a small percentage, the credit for which may be attributed partly to the superheater, there are other items in which the McClellon boiler appears to a decided advantage as compared with the radially stayed.

Bearing in mind that the running speed of the two engines was the same, and that the equated tonnage of the 3500 was 3.2 per cent above that of the 3324, we find a decrease of 10.7 per cent in the total coal fired, and almost the same decrease in the amount of coal fired per sq. ft. of grate. Partly the boiler and partly the engine

must be credited with the 15.1 per cent saving in the dry coal burned per 1000 gross ton miles. But wholly to the boiler must be credited the increase of 12 per cent in the actual evaporation per pound of dry coal and the increase of 11.5 per cent in equivalent evaporation, to which

This increased efficiency of 9.4 per cent over the standard boiler of engine 3324, which when added to the decrease of 7.2 per cent in pounds of water per I.H.P. hour would indicate a total over all increase in thermal efficiency of 16.6 per cent. However, due to the increased boiler



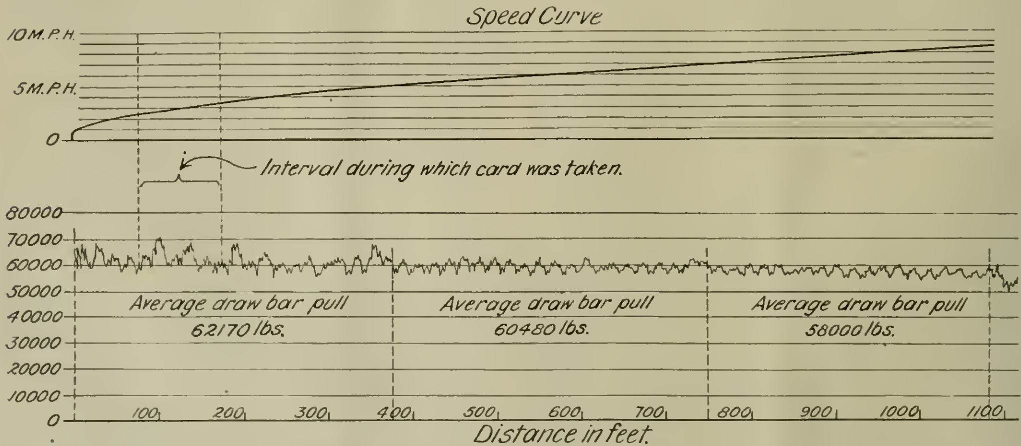
Profile of the New York, New Haven & Hartford Railroad From New Haven to Providence

must be added the 2.5 per cent increase of actual evaporation per sq. ft. per hour of evaporating heating surface. These figures gives the reason for the 9.4 per cent increase of boiler efficiency, and probably had much to do in determining the choice of the McClellon boiler for the ten new engines now on order.

No material difference in superheat was noticed on en-

pressure of engine 3500, there is a resulting loss in machine efficiency of 1.1 per cent, leaving a total overall thermal efficiency of 15.5 per cent.

Reverting to the total of engine and boiler performance, an indicator card is given which was taken at a time when the engine was hauling 4,496 tons in 85 cars up a .40 per cent grade at a point just east of Saybrook, indicated on



Dynamometer Record of Locomotive No. 3500 Fitted with the McClellon Water Tube Boiler at Saybrook, Conn., Hauling 4496 Tons in 85 Cars

gine 3500 with the McClellon boiler, than with the standard boiler of engine 3324.

Due to the high boiler pressure and limited cut-off of engine 3500, a saving of 7.2 per cent in pounds of water per I.H.P. hour was obtained, which when added to the 12.0 per cent increase in pounds of water evaporated per pound of coal, resulting in a decrease of 19.6 per cent in dry coal per I.H.P. hour

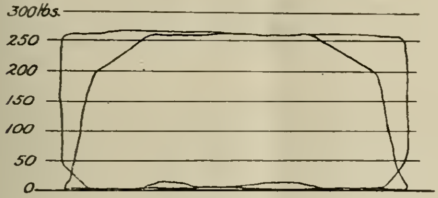
the profile at *A*.

The indicator card shows a cut-off at 70 per cent of the stroke, when the speed was 3 miles per hour, and the section of the dynamometer car chart shows a very uniform drawbar pull and acceleration of the train while the speed was being raised up to about 8½ miles per hour.

The tests of this engine and boiler are not yet completed and it is expected that further details regarding

the same will be published in one of the future issues.

Among other things the full hauling capacity of the engine has not yet been determined because there is no siding on the road that is long enough to permit of the make-up of a train with a sufficient number of cars to tax the engine to its limit.



INDICATOR CARD

Boiler Pressure 260 Lbs.—Cut-off 70 Per Cent—Speed 3 Miles Per Hour—Mean Effective Pressure, Front 231.3 Lbs., Back 235.1 Lbs. —Indicated Horse Power 587.6—Indicated Cylinder Tractive Effort 7,950 Lbs.—Dynamometer Tractive Effort 62,830 Lbs.—Engine Friction 5,120 Lbs.

The following shows a comparison of the outstanding items in the average results from engine 3324 and engine 3500:

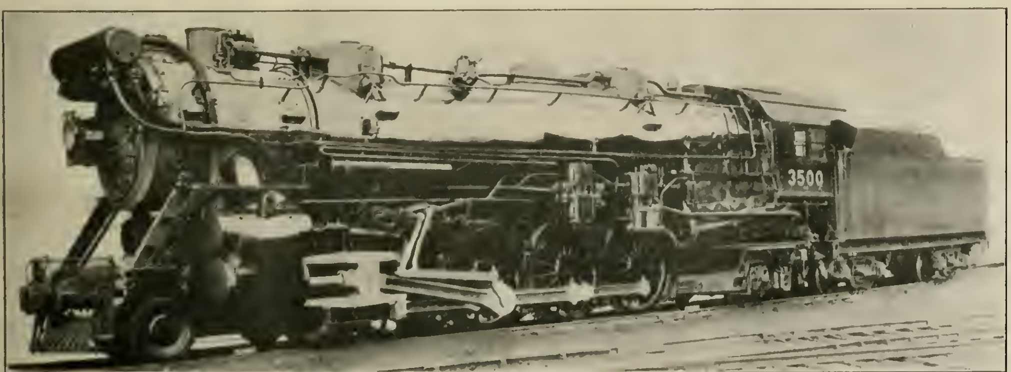
	Engine 3324 Average	Engine 3500 Average	Percent. Difference
Running time, mins.	254.0	254.0	
Running speed M. P. H.	25.3	25.4	+ .4
Number of train cars	90.5	87.0	— 3.9
Number of actual tons	4,360.6	4,556.0	+ 4.48
Number of equated tons	4,486.5	4,640.0	+ 3.2
Average cut-off per cent of stroke.	44.8	38.5	—16.5
Average I. H. P.	2,503.8	2,695.0	+ 7.67
Average D. B. H. P.	2,105.4	2,244.0	+ 6.58
Average D. B. H. P. Corrected for Grade and Curve	2,203.4	2,347.0	+ 6.52
Temp. Steam chest, deg. F.	571.7	588.2	+ 2.88
Degree of superheat	192.5	196.7	+ 2.18
Coal fired, Total	23,725	21,400	—10.7
Dry coal per sq. ft. grate surface per hr. lbs.	77.6	70.0	— 9.8
Dry coal per I. H. P. hr. lbs.	2.20	1.84	—19.6
Dry coal per D. B. H. P. hr. lbs.	2.95	2.50	—18.0
Dry coal per 1,000 gross ton miles	49.96	43.41	+15.1
Actual evap. per lb. dry coal	7.81	8.75	+12.0
Equivalent evap. lb. dry coal	10.32	11.50	+11.5
Actual evap. per hr. per sq. ft. evaporating surface, lbs.	10.4	10.64	+ 2.5
Lbs. water evap. per I. H. P. per hr.	17.18	16.03	— 7.2
Lbs. water evap. per D. B. H. P. per hr.	22.95	21.80	— 5.4
Boiler efficiency	74.59	81.53	+ 9.4
Machine efficiency	88.00	87.00	— 1.1
Thermal efficiency	6.46	7.47	+15.5

Railroads Continue to Buy Gas-Electric Equipment

That the gasoline electric car is gaining prestige as an acceptable solution of the branch line problem confronting many railroads, is evidenced by the number of such equipments that have been completed or are on order. The Westinghouse Electric & Manufacturing Company is now building electrical equipment for passenger cars and switchers of this type. The apparatus is mounted on cars built by the J. G. Brill Company, at whose plant it is also installed. The gasoline engine mounted in these cars has a rating of 250 hp. Tractive effort to the wheels is obtained by two railway type motors mounted on the forward truck and connected to the two axles through helical gears. Power for the motors is supplied from a 160 kw. generator which is directly connected to the six-cylinder gasoline engine specially designed for railroad branch line work. The first of these cars was completed for the Reading Company. Cars have been sold also to the Great Northern, Pennsylvania, New York, Ontario & Western, Boston & Maine, Erie, Long Island; New York, New Haven & Hartford, and other railroads, which indicates that they may be economically substituted for the steam locomotive in several classes of service.

Illinois Central Celebrates Its Diamond Anniversary

On February 10, the seventy-fifth anniversary of the establishment of the Illinois Central System, the parent road having been chartered on that date in 1851. The original 705½ miles of line have been extended to 8,500 in fifteen states of the Middle West and the South. In 1856, the year the original railroad was completed, it owned 83 locomotives, 52 passenger cars, and 1,246 freight cars, and represented an investment of about $26,000,000; at present the system owns 2,300 locomotives, 2,300 passenger cars, and 79,000 freight cars, and represents an investment of more than $720,000,000. Speaking of what has been accomplished in the years that are gone, President C. H. Markham, in a recent letter to the public, says: "But it is not the policy of the Illinois Central to dwell overlong upon the past. The daring which brought the Illinois Central into being as the then longest railroad in the world has left it a heritage of constant progress which has maintained in it the spirit and vigor of youth."



Locomotive No. 3500 of the New York, New Haven & Hartford Railroad Equipped with the McClellon Water Tube Boiler

A Comparison of Diesel and Steam Locomotives*

By Samuel M. Vauclain, President, Baldwin Locomotive Works

The steam locomotive has dominated transportation about one hundred years. It has been improved steadily. Its performance, through increased tractive power, has met the needs of modern transportation arising from the remarkable development of the world in the past fifty years. As a single, self-contained power unit, it is without equal so far as its general efficiency and low cost of production are concerned.

When discussing railway motive power, the standard of comparison must be the steam locomotive, which occupied a strongly entrenched position both from practical and sentimental viewpoints. Its simplicity, ease of control and action under widely varying conditions of load are factors that its rivals must embody if they are to compete successfully with it in every day service.

With the efficiency of modern internal combustion engines before him, the designer of railroad motive power naturally is attracted by their possibilities. Thermal efficiency of these engines runs as high as 33 per cent, while the best steam locomotive gives about one-fourth of this performance. Even with this handicap, the steam locomotive is a remarkably flexible and reliable traveling power plant. To compete properly, no matter what the fuel economies may be, the internal combustion locomotive must approximate this flexibility and reliability. It must have ease of control, ability to start a full tonnage train, and be able to adapt itself rapidly to change in the physical conditions met in operation, such as variable speeds, gradients, curves and weather conditions. It must not be too complicated in detail, nor too heavy for the horsepower developed. Here then are the basic features the designer must bear in mind constantly. While a gain in thermal efficiency will warrant an increase in first cost, the price must not be so high as to offset the reduced operating costs.

European experience in Diesel locomotive construction has been more extensive than that of the United States, and some late opinions on comparative costs are interesting. J. W. Hobson, of R. & W. Hawthorne, Leslie & Co., says, in England, the cost of Diesel locomotives with hydraulic transmission has averaged about 1.48 times the cost of a steam locomotive of equal capacity, complete with tender; that the same measure of comparison for a Diesel-electric locomotive yields a ratio of 1.9. Dr. Herbert Brown, of the Swiss Locomotive & Machine Works, Winterthur, Switzerland, says continental figures, on the same basis, yield an average cost for the Diesel-electric locomotive equal to 1,783 times the cost of the steam unit.

The problem divides itself naturally to cover two general classes of power; self-propelled vehicles for light traffic, and locomotive units for hauling trains equal in tonnage to those hauled by steam locomotive.

In applying Diesel heavy oil engines to true locomotive units, the first consideration must be weight per horsepower developed. The heavier classes of Diesel engines in stationary service weigh from 170 lbs. to 350 lbs. per horsepower. In locomotive service the weight of the engine must be added to the weight of transmission, running gear and vehicle body. If a 1,000 hp. Diesel engine of 170 lbs. a horsepower is used in a locomotive its weight of 170,000 lbs. would exceed the total weight of a complete steam locomotive of like capacity. During the World War some Diesel engines, showing a horsepower for every 65 lbs. of engine weight, were built for submarine service. The locomotive designer needs this type of machine. The 1,000 hp. rated Diesel-electric locomotive, built in Germany for the Russian railways (1924) has a total weight of 275,000 lbs., or 275 lbs. per horsepower.

The 1,000 hp. rated Diesel-electric locomotive built in 1925 by the Baldwin Locomotive Works also weighs 275 lbs. per horsepower. This indicates a close coincidence of best European and American practice and sets, for the present, this weight per horsepower as the standard for modern Diesel-electric locomotives. A slight decrease in weight is possible with an advance in locomotive horsepower; the present expectation in this respect is about 220 lbs., which represents a ratio of about 1:1.5 when compared with an average steam locomotive. With a thermal efficiency of 3:1 in favor of the Diesel engine it appears that the added weight per horsepower is not a severe handicap. Ratios of this character, provided they go hand in hand with simplicity, should show attractive operating economies. What then should be the features tending toward simplicity of maintenance?

In discussing this phase of design it is advisable to review the history of internal combustion locomotives. It will be found the means of coupling, or transference of power from the prime mover to the driving wheels, is of greatest importance. The first real Diesel locomotive was that designed in 1909 by Adolph Klose, of Berlin, and constructed jointly by Sulzer Bros., of Winterthur, Switzerland, and Borsig, of Berlin-Tegel, Germany. To show the boldness of the design, which was for 1,000 hp., it should be compared with what is believed to be the first internal combustion locomotive ever constructed, the Daimler engine of 1891. As Dr. Diesel's oil engine had not been invented, this prime mover was one of the earliest types of internal combustion motor and developed only four horsepower.

The First Diesel Locomotive

Dr. Diesel's experiments with compression ignition began in 1893, but it was not until 1897 that the engine was considered of commercial value. The development had taken four years, and cost about $107,000. One of the earliest concerns to manufacture this type of prime mover was the firm of Sulzer Bros. of Winterthur, Switzerland. It followed naturally the first attempt at designing a full powered locomotive unit driven by a Diesel motor should be attempted by them. Associated with Sulzer Bros. were Dr. Diesel and Adolph Klose, who previously had coöperated with Diesel. In an effort to approximate the simplicity of the steam locomotive they coupled their engine directly to the driving gear by means of a jack shaft.

The steam engine, having its source of power generated outside the cylinder, will start directly under any load within its capacity, and can be controlled entirely by a steam inlet valve (throttle). The internal combustion engine, which generates its own source of power directly within its cylinders, must have auxiliary starting means, and is operated preferably without load until proper thermal conditions are established. Here, then, lay the problem of the first design: How to get a running start, and still maintain direct driving, with a speed beginning at zero under load.

*Abstract from a paper presented at Midwest Power Conference, Chicago, Ill., January 29, 1926.

Direct Drive a Failure

Much of the history of this locomotive is obscure, as it was constructed at a period unfortunate for proper experiment and record. Beginning the design about 1909 it was not completed and ready for trial until 1913. It was intended for use on the Hesse-Prussian state railways in Germany. As it fell upon war times in 1914, its ultimate disposal is not now known generally. The direct drive proved a failure, but the experiment warned future designers against similar error. It proved positively that the Diesel motor could not be used advantageously for a direct drive in locomotive construction.

This pioneer Diesel locomotive is reputed to have weighed 95 metric tons (207,000 lbs.), and as its rating was 1,000 hp., the weight per horsepower was 207 lbs. It was the 4-4-4 type, with two pairs of drivers and four-wheeled trucks, both leading and trailing. Its main motor was the two cycle, single acting type, with cylinders 15 in. in diameter, by 21½ in. stroke, suspended in V form, longitudinally with the locomotive, and driving a transverse jack shaft with cranks located at 180 degrees.

As it was not self-starting, it was equipped with an auxiliary Diesel motor which could develop about one-fourth the power of the main motor. This auxiliary motor compressed air to a pressure between 600 and 1,000 lbs. to the square inch. The air was stored in a battery of reservoirs, and used for starting both motors. The locomotive was driven by air pressure in the cylinders until a speed of 6½ miles an hour was attained. This speed was calculated as sufficient to produce compression and ignition of the oil fuel, which was then injected into the cylinders. In regular operation, the supply of compressed air was kept up by a multistage air pump, operated by pistons, placed in the V-space between the motor cylinders, and coupled to the main driving mechanism by means of links and rockers. The exhaust muffler and coolers for jacket water were placed longitudinally in the cab roof. The cab enclosed the entire machine.

Road tests were made on the Swiss federal lines between Winterthur and Romanshorn, and a speed of 62.5 miles an hour was attained. The air starting system gave considerable trouble, as the auxiliary engine was unable to supply the needed air. Irregularity firing at low speed is reported also. This contributed, doubtless, to the breaking of the jack shaft which failed in 1913. The road tests were transferred to the Berlin-Mansfeld line of the Prussian state railways early in 1914, and further record was lost in the hurly burly of war.

Internal combustion engines must be operated at speeds within their range of efficiency; and not from a zero start, as in direct connection. The designer, therefore, must find proper means for connecting the running prime mover to the locomotive driving mechanism. This transfer of power can be accomplished in three ways: (1) By mechanical (stepped gearing) transmissions; (2) hydraulic (flued pressure) transmission; and (3), transmission of power by electricity.

Mechanical Transmissions

These are the ordinary change-speed stepped gearing, as applied in automobile practice. In locomotive construction they should be arranged preferably to give the same range of speeds forward and backward. Reversing is accomplished usually by bevel gearing. Mechanical transmissions require some sort of a friction clutch, and this feature gives trouble on the upper range of power. Probably 150 horsepower is the practical limit for mechanical transmission.

Hydraulic Transmission

This form of transmission employs oil as a power transference medium usually. It is attractive because of the possibility of infinite speed variations; some designs, however, fail to secure this possibility. Hydraulic transmission is suitable for locomotives of comparatively high power and is of lower first cost than electric transmissions of equal capacity. It has the disadvantage of concentrating its final driving power into one gear wheel, making it dependent on tooth contact and pressure. Its limitation is about 500 horsepower, although its advocates say it is adaptable to twice this figure. All designs employ a primary unit, or pump, which supplies oil under pressure to a secondary unit, or rotor. If the stroke of the pistons in the primary unit permits variation from zero to maximum, it follows that variability of speed can be obtained in the secondary unit, which is practically of reverse operation to the primary unit. The Hele-Shaw and Lentz transmissions are the best known examples of hydraulic transmission.

Lentz System

The Lentz system, usually considered the most successful, does not give infinitely variable speeds. Because of simpler construction and the lower oil pressures, it avoids the operating mishaps of more complicated systems. It gives a definite number of primary speeds; intermediate speeds are obtained by by-passing the transmission oil, or by varying the speed of the main motor. As the oil pressures in the Lentz gear do not exceed 500 lbs. a square inch at starting, and average 50 to 150 lbs. when operating at speed, leakage is not so serious as with the other types of hydraulic transmission. Many European locomotives have been fitted with the Lentz gear.

The Schneider system is really a combination of mechanical and hydraulic transmission. The increased torque required at low speeds is obtained from the relative motion between the rotor and its casing. The energy due to slippage augments the power by an additional torque on the secondary unit. By this arrangement the usual power losses in hydraulic transfer are decreased and the general efficiency of the transmission is improved, especially at the higher operating speeds. The Schneider system is being exploited by the Swiss Locomotive & Machine Works, of Winterthur, which has constructed also a special 500 horsepower Diesel engine, which, with the transmission, is assembled into a complete locomotive unit. No reports of its trials are available.

Electric Transmission

In this system the prime mover is connected to an electric generator which supplies current to operate suitably disposed driving motors. Electric transmission gives a continually variable gear, allowing the locomotive to adapt itself advantageously to the speed of the prime mover. It makes driving easy and can be adapted easily to double end control. The installation is expensive, but from the railway operating viewpont it is the most attractive transmission. Within recent years a number of Diesel-electric locomotives have been built in Europe and the United States.

The Lomonossoff Locomotive

That which has attracted most attention in Europe is the design by Professor Lomonossoff constructed at Dusseldorf, Germany, for the Russian Government Railways. It has a 2-10-2 wheel arrangement with five motor driven axles. It is arranged for double end control, with the drivers' cabins over the carrying trucks. The engine is a

Diesel submarine type four-cycle, six cylinder unit, with compressed air fuel injector. Its normal speed is 450 revolutions a minute; and with a maximum capacity of 1,200 horsepower. The locomotive unit itself is rated at 1,000 horsepower and to verify this rating the machine was tested thoroughly on a special plant similar to that of the Pennsylvania Railroad at Altoona, Pa. These trials form the subject of an elaborate discussion by Professor Lomonossoff, which has been translated into German and published under the title of "Die Diesel Electrische Lokomotive." All electrical machinery is from the Swiss firm of Brown, Boveri & Co., briefly described as follows:

The generator has capacity of 800 kw., at 600 to 1,100 volts, and is coupled directly to the prime mover by a flexible coupling. The exciter, carried on the end of the generator shaft is excited by an auxiliary dynamo operated from a storage battery. A peculiarity of the locomotive is its cooling system. The water flows through a piping system cooled by a fan. This is reported to be sufficient during "winter and ordinary temperatures." Summer operation is such as are common in Russian Turkestan (120 deg. F.) will so overload the cooling system that a "cooling tender" must be used. This carries extra radiating equipment with fans driven by an auxiliary Diesel engine. If the weight of the extra cooler is considered, its thirty metric tons would make the engine figure 340 lbs. per horsepower. This feature certainly is not in line with the all around utility ideas common with railway men in the United States.

The Lomonossoff locomotive was assembled at the Hohenzollern Locomotive Works, Dusseldorf, Germany, where tests were made on the roller plant. A comparison of these tests with those of a Russian type 0-10-0 oil fired steam locomotive was made. Dr. Herbert Brown of Winterthur, reports an average overall thermal efficiency of 7.43 per cent for the steam locomotive and 26.4 per cent for the Diesel-electric. This shows the Diesel locomotive to have been over 3½ times as efficient as the steam locomotive. These are significant figures when first cost and maintenance charges are to be considered. Dr. Brown estimates the prime mover, including its auxiliaries, take about 44 per cent of the total weight; the electrical equipment 30.5 per cent; leaving for the mechanical structure and running gear only 25.5 per cent.

Recent internal combustion locomotive construction in the United States has been along the lines of electric transmission only.

The Baldwin Locomotive Works produced a Diesel-electric locomotive of 1,000 horsepower in 1925. The prime mover is a two cycle, solid injection engine, of peculiar construction and very light weight. This machine represents the largest unit yet attempted in the United States. It is the result of extensive research and experimentation to fulfill the requirements of a reliable self-contained unit, of simplest possible ensemble and ease of control. It weighs 275,000 lbs. (275 lb. per horsepower) and is mounted on two six-wheeled trucks. Traction motors are applied to four of the six axles. Its electrical equipment is of Westinghouse manufacture, with electro-pneumatic and magnetic controlling mechanism arranged for double end operation. The Diesel engine is the inverted V type with twin crank shafts geared to a central shaft on which is mounted the electrical generator. It is undergoing intensive tests at the yards of its builders and on adjacent railway lines at present.

Considerable time must elapse, and many millions of dollars be expended, in the development of the oil-electric locomotive before it will affect transportation service to any great extent. It has many apparent advantages that are not only of great interest to railway men, but very seductive to those who do not understand clearly all that is involved. At present construction costs are as two to one compared to steam power.

The internal combustion locomotive unit, whether constructed with direct drive hydraulic or electric transmission, is yet in its infancy. The best engineering talent of the world is bending its energy to a successful solution of the problem. We will not know what difficulties in operation and safety will be encountered, until an appreciable number are in actual operation. The introduction of electric power for transportation purposes has been slow. The expense of installation, and the inconvenience and obstruction incident to its application, in switching yards and large railway terminals have militated against it. It has progressed step by step and is a necessity for all underground transportation, and for increasing the volume of traffic over sections of railway on which the steam locomotive has reached its limit.

If it be possible to produce a satisfactory machine at a price satisfactory to the purchaser, its greatest effect upon the transportation methods of the country will be to further the electrification of railways in general. This experiment is being tried in Switzerland now. If by the use of internal combustion locomotives all branch line and distributing service at railway terminals can be accomplished satisfactorily, and only main line service by overhead wires or third rails be required, we can then expect a more rapid development in the electrification of railways. It will be many years before the steam locomotive, owing to its simplicity, its serviceability and its low production cost will be relegated to the era of the past.

The East Indian Railways

India consists of three separate and well-defined tracts. The first of these three regions is the Himalaya mountains and their offshoots to the southward, comprising a system of stupendous ranges, the loftiest in the world. The wide plains watered by the Himalayan rivers form the second of the three regions. The third comprises the three-sided table-land which covers the Southern half or, more strictly, peninsular portion of India, and is known as the Deccan.

It is thus evident from the very nature of the country that the railways have to traverse wide level stretches as well as difficult mountainous sections. The steep ascents from the Coast are well known and especially heavy tank locomotives, the so-called Ghat engines, are built for this service. It is less well known, however, that on the broad gauge lines to the Bolan Pass on the North Western Railway there are long 4 per cent grades up which trains of 640 tons are hauled by 2-6-6-2 articulated mallet locomotives assisted by two heavy 2-8-2 tank pusher locomotives.

As for distances in India, they are not as great as in the United States, but they are, by no means, insignificant. For example, from Calcutta to Delhi, it is something more than 800 miles; from Delhi to Bombay it is about 750 miles and from Bombay to Colombo it is some 875 miles.

Railway construction was begun at nearly the same time at the three principal ports of Calcutta, Bombay and Madras. In 1853 the Bombay-Thana line of 20.5 miles was opened, and the same year saw the opening of the Calcutta-Hooghly line of 23.5 miles, and, in 1856, the Madras-Arcot line of 65.5 miles was opened. By 1859 there were eight companies engaged in the construction of more than 5,000 miles. These were the East Indian Railway; Great Indian Peninsula Railway; Madras (and Southern Mahratta) Railway; Bombay, Baroda & Central India Railway; Eastern Bengal Railway (sub-

sequently E. B. State Railway); Oudh & Rohilkund Railway (subsequently O. & R. State Railway); Sind, Punjab & Delhi (North Western State) Railway and the Great Southern of India (South Indian) Railway.

Of this group of great railways, the Oudh & Rohilkund Railway disappeared on July 1st, 1925, by merging into the East Indian Railway, which had itself been taken over as a State Railway on January 1st, 1925, and the Great Indian Peninsula Railway was also taken over later.

The Indian railways are mainly State-owned, but, to a small extent they are privately owned; in some cases the railways mainly owned by the State are worked by private companies, as is, for instance, the case with the Bombay, Baroda and Central India Railway, the Madras and Southern Mahratta Railway, and others. In addition, some of the railways are the property of the Indian states.

At first only the broad gauge (5 ft. 6 in.) was used; but, in 1870, it was decided to permit the use of a narrower gauge for railways of secondary importance. The metre gauge (3 ft. 3⅜ in.) was then adopted, and it was the railways of this gauge, that, in later years, developed most rapidly, notwithstanding the fact that the permissible axle load has thus far, in most cases, been limited to from 8 to 9 tons as against 18 tons that is used on the broad gauge lines. Later on the 2 ft. 6 in. and the 2 ft. gauges were adopted for the smaller railways. The best known 2 ft. gauge railway is from Siliguri, at the foot of the Himalayas, and running for a distance of about 51 miles to Darjeeling which it reaches at a height of about 6,800 feet. There is also the Gwalior light railway having a length of 250 miles.

The extension of the railway system was hastened by the famine of 1877-78.

Of the two acompanying tables, Table No. 1 gives a general idea of the development of the railway system. The metre gauge lines already comprise about 10,000 miles or, in other words, about 40 per cent of the total system. Table No. 2 gives a few figures relating to the corresponding number of locomotives.

For fifty years English firms supplied the rolling stock except for an order for 20 engines which was filled in Germany and delivered in the years 1867 and 1869 by the Esslingen Machinenfabrik, and another order for 10 engines which was filled in 1867 by the well-known Swiss firm of Escher, Wyss & Co.

TABLE No. 1

(Length of Railways in Miles)

Year	Gauges 2 ft. 0 in.	2 ft. 6 in.	Metre	5 ft. 6 in.	Total
1855					169
1860					838
1875					6,531
1880					5,162
1885					12,283
1889					15,245
1900					23,763
1912		2130	14,165	15,189	33,484
1924	621	1595	15,118	22,531	39,865

TABLE No. 2

(Number of Engines)

	2 ft. 0 in.	2 ft. 6 in.	Metre	5 ft. 6 in.	Total
Dec. 31, 1909	78	220	2209	4517	7034
" " 1911	312		2347	4756	7413
" " 1924	115	402	2748	6848	10,111

It was not until 1901, when the English Works were booked to their full capacity, that German firms succeeded once more in getting a share of the locomotive supply to British India. The largest portion of the orders then fell to the Hanomag, which works delivered 44 broad gauge 0-6-0 type freight locomotives to the East Indian Railway and ten metre gauge 2-6-0 type mixed engines to the Assam Bengal Railway. *Hanomag Nachrichten.*

Welded Locomotive Tenders

Electric arc welding as a method of constructing locomotive tender tanks, instead of the customary riveting process, offers a prospect of a better product and reduced cost, according to results obtained by the Boston & Albany Railroad. In January, 1921, this road built at its West Springfield, Mass. shops a locomotive tender tank constructed throughout by General Electric arc welding equipment, with the exception of the safety appliances (grab handles). This tank was mounted on a Commonwealth Steel frame, arch bar trucks, on a Pacific locomotive, No. 513, and placed in service February 6, 1921. Since that time it has covered a distance of 201,563 miles with no defects having developed in the welding.

With the arc welding method of construction practically all laying out, punching and drilling of sheets, angles and T-braces, together with reaming, riveting and caulking, are eliminated. The Boston & Albany tank was made of ¼-inch plate with the following dimensions; 26 feet long, 10 feet wide and 5 feet 2 inches high.

In the average tank of this capacity there are approximately 7,000 rivets with a total weight of 800 pounds and the number of holes punched in sheets, angles and T-braces would total approximately 15,800. In the Boston & Albany tank there is a total of 1185 feet of welding, the welding rod consumed totalled approximately 398 pounds.

In order to eliminate the water scoring and rusting, prevalent in the riveted type of tank, the welding of T-braces to the bottom and top of the tank was continuous in its entire width.

New York Central Diesel Locomotives

After thorough investigation into the various types of Diesel locomotives, two new ones, radical departures from the existing types of locomotives to be used for main line freight haulage and high speed passenger train service, are being constructed for the New York Central Railroad. They will probably be put into service on the Putnam Division some time in August or September.

The contracts were awarded in November, 1925, one was for a freight oil-electric locomotive, weighing 128 tons. It is to be equipped with a 750-horse-power Ingersoll-Rand Diesel engine furnished by the General Electric Company. This contract went to the American Locomotive Company.

The McIntosh & Seymour Corporation was awarded the other contract, calling for a passenger type oil-electric locomotive, weighing 148 tons and equipped with an 800 horse-power McIntosh & Seymour Diesel engine. The mechanical parts of the locomotive are to be furnished by the American Locomotive Company and the electric transmission by the General Electric Company.

If the trial locomotives are successful the contracts carry options for the entire number of locomotives required for the main line of the Putnam Division of the New York Central for operation between Sedgwick Avenue, New York City, and Brewster, N. Y.

It is interesting to note that these are the first orders to be placed in this country for Diesel electric road locomotives. The other locomotives tested by the New York Central engineers in use in this country are for switching service, not being suitable or intended for main line freight haulage or for high-speed passenger trains.

These locomotives are self-contained power units, using electricity generated by Diesel oil engines, as the driving power, applied through motors of the ratings given. The Diesels use a low-grade oil as fuel, and a number of them of varying designs are now in service.

Progress of the Investigation into Power Brakes and Appliances for Operating Power Brakes

The American Railway Association is now making a thorough investigation of power brakes and appliances for operating power brake systems for freight trains on its one-hundred car test rack located at Purdue University, Lafayette, Indiana. The tests were started on November 30, 1925, and will continue until all power brake equipments under consideration have been tested.

Reason for the Investigation

For some time past the Interstate Commerce Commission has been carying on an investigation of power brakes and appliances for operating power brake systems and, in its preliminary report and conclusions, dated July 18, 1924, stated that improvements in the operation of power brakes are essential and must be effected. This report further outlined several general requirements and test requirements which, in the opinion of the Commission, were essential features of a suitable power brake.

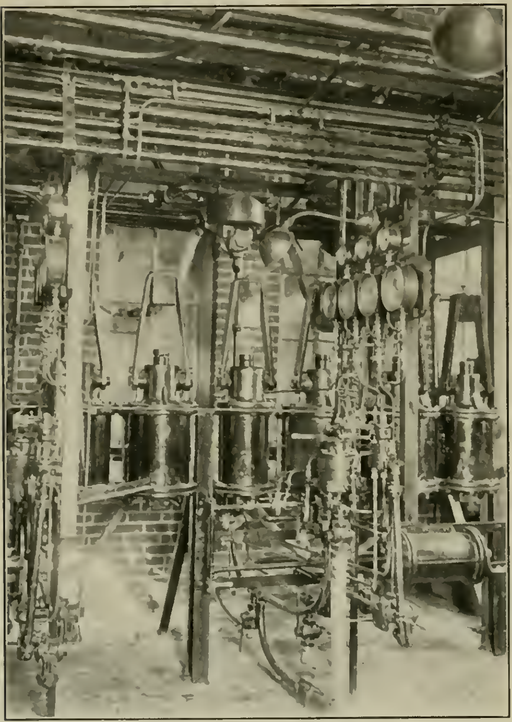


Fig. 1 Shows a Part of the New Locomotive Rack and More Especially the Automatic and Independent Brake Valves of Locomotive No. 2, the Locomotive and Tender Brake Cylinders, Gauges, Vent Valve and Piping

The requirements set forth in these tentative specifications were as follows.

Test Requirements

Triple valves for freight service shall conform to the following requirements when tested on a test rack representing the power brake equipment of a one-hundred car train, tests being made from an initial brake pipe pressure at the brake valve of 70 lbs.

1. With a service reduction of 5 lbs. in brake pipe pressure, all brakes must apply.

2. With a service reduction of 10 lbs. there must be not more than 25 seconds difference in the time of obtaining 10 lbs. pressure in the brake cylinders of the 1st and the 100th brakes.

3. A total brake pipe reduction of 25 lbs. must result in equalization of brake cylinder pressure with pressure in the reservoir from which compressed air is supplied to the brake cylinder, and brake cylinder pressure of not less than 48 lbs. nor more than 52 lbs. must be obtained.

4. With piston travel of 8 inches, a service reduction of 10 lbs. must result in pressure in each brake cylinder of not less than 15 lbs. nor more than 35 lbs. and with brake valve in lap position pressure in each brake cylinder must be maintained between these limits for a period of three minutes. In a full service application, after the specified maximum brake cylinder pressure has been obtained, brake cylinder pressure must not be reduced below 45 lbs. within a period of three minutes.

5. With an emergency reduction of brake pipe pressure, pressure in all brake cylinders of 5 lbs. or more must be obtained in 6 seconds from the time of movement of the brake valve to emergency position, and maximum pressure in all brake cylinders, which shall be not less than 15 per cent nor more than 20 per cent above the pressure given by the same brake in full service application, must be obtained in 9 seconds from the time of movement of the brake valve to emergency position.

General Requirements

The following requirements for power brakes and appliances for operating power brake systems are specified and prescribed:

1. That only a service application of the train brakes will occur when a service reduction of brake pipe pressure is made.

2. That effective emergency brake cylinder pressures will be obtained when an emergency reduction of brake pipe pressure is made from a fully charged brake system.

3. That effective emergency brake cylinder pressures will be obtained when an emergency reduction of brake pipe pressure is made after a full-service brake pipe reduction has been made.

4. That effective emergency brake cylinder pressures will be obtained when an emergency reduction of brake pipe pressure is made following release after a full-service brake application.

5. That means will be provided whereby an engineman can control the release of pressure from brake cylinders and effect such release by graduated steps or gradually in order that he may decrease as well as increase brake cylinder pressures as required to control at relatively uniform rates the speed of trains.

6. That means will be provided for obtaining and maintaining brake-cylinder pressures within prescribed limits for specified periods of time during brake applications.

7. That apparatus conforming to the foregoing re-

quirements shall be so constructed, installed and maintained as to be safe and suitable for service.

As these requirements contained functions which are not present in the standard freight train brakes in general use, the American Railway Association agreed to make a thorough and unbiased investigation to determine if the views of the Commission could be met. Accordingly a director of research was appointed by the American Railway Association in December, 1924, who was instructed by the Committee on Safety Appliances of the Mechanical Division to proceed upon the following plan:

1. Steps will be taken to obtain appliances which, it is claimed, meet the views of the Interstate Commerce Commission, as indicated in its preliminary report and conclusions. If the plans or specifications for such appliances are available and the appliances are not yet being manufactured, steps will be taken by the Director of Research to secure such appliances, even to the extent of entering into an agreement to have such appliances made.

2. As soon as such appliances have been obtained they will be given exhaustive tests on the test rack at Purdue University, which rack will be completely prepared and brought up to date for the purpose of this investigation.

3. Following the completion of the rack tests such devices will be given road tests, to develop whether or not they meet road conditions safely in service.

4. This program will be carried out with all dispatch and as promptly as the devices for these tests are available.

5. The investigation will also embrace such further study as may, in the judgment of the Director of Research, throw further light upon this problem.

Progress of the Work

Following the above plan, the American Railway Association addressed inquiries to the air brake manufacturers to ascertain if they would design and build air brake equipments which would meet the views of the Interstate Commerce Commission. In response to these inquiries two air brake manufacturers, the Automatic Straight Air Brake Company and the Westinghouse Air Brake Company, agreed to furnish such equipments and in February, 1925, the American Railway Association placed an order with each of these companies for 150 sets of freight train air brake equipments for trial purposes. The Westinghouse Air Brake Company will also submit a second air brake equipment embodying its views as to the desirable functions of an air brake equipment for modern freight train operation.

Ever since the orders have been placed, the manufacturers have been busily engaged in designing and building the equipments which they intend to submit. Up to the present time neither of the manufacturers has submitted its apparatus. It is anticipated that the Automatic Straight Air Brake Company will be ready to ship its equipment during the month of February 1926 and that the Westinghouse Air Brake Company will ship its equipment shortly thereafter.

In the meantime the test rack has been completely rebuilt, new recording instruments designed and installed, a basic schedule of tests developed and agreed upon by the various parties concerned in the investigation and tests on the type K equipments started.

It was decided to make the same tests with the present standard air brake equipment for freight trains, known as Westinghouse Type K, as will be made with the new equipments in order:

1. To obtain accurate information concerning the functioning of this equipment,

2. To establish its advantages and short-comings,

3. To obtain a basis with which the new equipments will be compared so as to determine whether such new equipments represent sufficient progress in the art of train braking to warrant their adoption.

Preparing the Test Rack for the Investigation

The American Railway Association air brake test rack is located in a separate building approximately 35 feet wide by 100 feet long adjacent to the testing laboratories at Purdue University. It consists of two main parts, the locomotive rack and the car rack. It was necessary to dismantle the locomotive rack and move it to a new location in order to provide more space for the new sections of the car rack. The old locomotive equipments were re-

Figure No. 2 Shows a Close-up of the Gauges at the Brake Valve Operator's Position. The Special Electric Wiring for Recording the Movement of the Brake Valve Handle Can Be Seen on the Upper Part of the Automatic Brake Valve

placed with two new type No. 6-ET locomotive brake equipments, which are so installed that one or both locomotives may be used in the tests. Two new 8½ in. 150 cubic feet cross compound air compressors were installed near the locomotive rack and were so piped that either or both compressors could be used.

The old car rack was of sufficient size to accommodate 100 type K brake equipments but was not large enough for the new brake equipments which are to be tested. It was necessary to add four new sections to the car rack and equipments were arranged so that there would be five brake equipments in each section. During this re-arrangement of equipments, all piping was taken down off the rack, hammer tested, blown out, replaced on the rack and blown out again. All brake cylinders were taken down off the rack, cleaned, checked for wear, new packing cups installed and cylinders relubricated. All reservoirs were blown out and checked for leaks. The length of brake

pipe per car was increased from 42 feet to 50 feet since the latter figure represents present day conditions in freight equipment. All hose and gaskets were replaced with new material. In other words, the entire rack was given a complete overhaul.

A new recording trainagraph was developed for this investigation. Each trainagraph is driven by a 110 volt, 60 cycle alternating current synchronous motor, so that all trainagraphs operate at the same speed. Each instrument has four pressure pens and four time pens. The four pressure pens automatically record the pressures in the brake pipe, brake cylinder, auxiliary and emergency reservoirs. Two of the time pens are electrically connected to a master clock and automatically indicate seconds on the charts, while the other two pens indicate on each chart the movement of the brake valve handle either to the service position or release position, whichever is desired. Since the brake valve event occurs at the same instant on all instruments, means are hereby provided for synchronizing

Fig. No. 3 Shows the Center Aisle of the Car Rack with the Locomotive Equipment at the End of the Aisle. This Shows the Brake Pipe Above with the Hose Connections Between Cars, the Brake Cylinders and Yokes and Oak Blocks for Obtaining the Various Length of Piston Travel. Car Equipments from No. 1 to 50 Are Shown on the Right and from No. 51 to 100 on the Left Side in This View

all charts to a common starting point, the movement of the brake valve to the operative position.

On eight cars distributed throughout the 100-car train the brake cylinders are equipped with circuit breakers so arranged that the electrical circuit is momentarily broken when the brake cylinder piston starts to move to application position and is again momentarily interrupted when the piston returns to release position. The operation of each of these circuit breakers makes an indication on the record chart for its respective car of the exact instant its brake cylinder piston started to apply and again when it returns to the release position.

A special locomotive trainagraph instrument was also developed to show at all times the position of the brake valve handle. This instrument also automatically records the pressures in the main reservoir and equalizing reservoir of the locomotive and the brake valve event as explained above for the car trainagraphs.

Thirty-four car trainagraphs and two locomotive trainagraphs have been built and installed on the test rack.

Five gauges have been installed at each car equipped with a trainagraph for the purpose of checking the pressures shown by the instrument. All gauges and trainagraphs have been calibrated and calibration curves prepared.

Mercury manometers were built and installed on cars No. 50 and 100 for the purpose of accurately measuring the brake pipe pressure at these cars in pounds per square inch and tenths thereof.

Three large storage batteries furnish direct current at 6 volts, 12 volts and 24 volts needed for the operation of the trainagraphs and the 110 volt alternating current is furnished by the University power plant. A very extensive system of electric circuits was installed on the car rack not only for lighting, but also for operating the trainagraph motors, the time and event pens and a trainagraph operator signal system. All of this wiring was installed in a metallic conduit with approved switches and outlet boxes.

After all the piping and equipment had been installed, the brake pipe leakage for the 100-car train was reduced to less than 2 lb. per minute. The leakage of each brake cylinder was also reduced to less than 2 lb. per minute. In certain tests, however, artificial brake pipe leakage of 7 lb. per minute and artificial brake cylinder leakages of 5 lb., 12 lb., and 17 lb. per minute will be created by means of fixed orifices.

The Basic Schedule of Tests

The first draft of the basic schedule of tests was sent to the following parties, who are concerned in this investigation, in the month of July, 1925:

Mr. W. P. Borland, Director of Bureau of Safety, Interstate Commerce Commission, Washington, D. C.

Mr. H. I Miller, Vice-President and General Manager, Automatic Straight Air Brake Co., New York, N. Y.

Mr. C. C. Farmer, Director of Engineering, Westinghouse Air Brake Co., Pittsburgh, Pa.

Mr. C. E. Chambers, Chairman, Committee on Safety Appliances, Mechanical Division, American Ry. Assn.

Mr. V. R. Hawthorne, Secretary, Mechanical Division, American Railway Association, for transmittal to the members of Committee on Brakes and Brake Equipment.

Shortly thereafter conferences were held with each of these parties to ascertain their criticisms and suggestions for new tests.

After all of these suggestions had been included in the second draft of the basic schedule of tests, it was again sent out in October 1925 to the parties referred to above for further criticisms, suggestions or approval. This draft was approved with some suggestions for additional tests. The basic schedule of tests is divided into the following main headings:

1. Individual Triple Valve Tests. (Single Car.)
2. 100-Car Train—Level Road Conditions—Direct Release.
3. 100-Car Train—Grade Conditions—Graduated Release or Retainers.
4. 50-Car Train—Grade Conditions—Graduated Release or Retainers.

The basic schedules of tests contains 565 separate tests which is indicative of the scope and extensiveness of this investigation. All equipments under consideration will be run through each test in this schedule. A large number of the tests in this schedule have been designed to reproduce conditions which are met in actual freight train service. The making of these tests in the research laboratory will result in the shortening of the time required to make the road tests.

The following freight train equipments will be tested on the rack.

1. Standard type K triple valves in order to determine the exact functions of present standard brakes for a basis of comparison with the new brake systems which will be tested.
2. Type K triple valves with heavier-than-standard graduating springs to determine the effect of these springs upon the functioning of the K triple valves.

3. Automatic Straight Air Brake equipment
4. Mixed equipments of standard type K triple valves and Automatic Straight Air Brake equipments.
5. New Westinghouse Air Brake equipments, which, in their opinion, meet the views of the Interstate Commerce Commission.
6. Mixed equipments of standard type K triple valves and new Westinghouse equipments.
7. A second new Westinghouse equipment embodying its views as to the desirable functions of an air brake equipment for modern freight train operation.
8. Mixed equipments of standard type K triple valves and the second new Westinghouse equipments.

An organization of trained men has been built up to carry on the test work. This orgainzation at the present time consists of thirty men, all of whom have been especially picked out for this work. No University students are being employed. The testing is being carried on continuously working 44 hours per week. While one force of men are making tests on the rack, another force of men are compiling the results from the records made in the research laboratory.

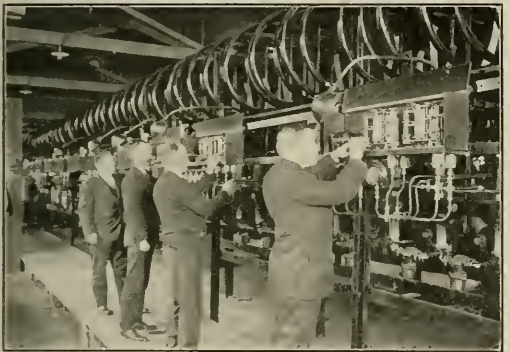


Fig. No. 4 Shows a Group of the Car Trainagraphs. In the Instrument in the Foreground the Alternating Current Synchronous Motor, the Two Charts, Gauges and Copper Pipe Connections Can Be Plainly Seen

Representatives of the Interstate Commerce Commission are present in the research laboratory at all times during the conduct of the tests. The air brake manufacturers have been invited to send representatives to be present not only during the testing of their own equipment but also during the testing of the other brake equipments under consideration.

Time Required to Complete Rack Tests

From the time being taken to test out the equipments under the first and second series, namely, the standard type K brake equipments and the type K brake equipments with the heavier-than-standard graduating springs, an estimate of approximately two months per equipment can be made. At this rate it will take practically all of the year of 1926 to complete the rack tests. Methods for reducing the time required to test an equipment are now under consideration.

It is expected that these tests will result in bringing about still greater safety and comfort to passengers as well as a reduction in loss and damage to both freight and equipment. The tests are being conducted under the direction of H. A. Johnson, director of research of the American Railway Association, and general manager of the Chicago Rapid Transit Company.

The Mechanical Section of the American Railway Association and Autogenous Welding

A year ago a letter ballot was submitted to the members of the Mechanical Division of the American Railway Association on what had been proposed as recommended practice by the committee on autogenous welding at the previous June convention. The recommendation was for the purpose of defining and limiting the use of autogenous welding in locomotive fireboxes. The suggestion was that no welding should be permitted in the crownsheets, except that they might be welded to the side sheets along a line not less than 12 inches below the highest point of the crown. This failed to receive the necessary two-thirds endorsement by a little over one per cent. Another proposition to permit the welding of cracks and transverse seams in the crownsheet was lost by a majority of almost two to one.

Then later in the year the chief locomotive inspector of the Interstate Commerce Commission issued a circular requiring that all autogenously welded seams within the cab and above the floor should be covered with a patch securely held in place by rivets, studs or patch bolts so as to prevent the escape of scalding water and steam in case the welded seam should fail.

Since the first of the year this circular has been withdrawn, but, with its withdrawal, the chief locomotive inspector has asked the roads to submit their rules for welding. This apparently gives the railways a free hand, for the time being, and that is one of the reasons for again submitting the original proposition to letter ballot which has now been done with the request that all votes be in by February 15.

In the resubmission of the subject an explanation has been added to the effect that the limitations originally suggested does not prohibit the welding of fire-cracks extending from rivet holes to the caulking edge of the sheet, and also explains that the attachment of thermic syphons to the crownsheet is not considered.

As has been repeatedly set forth in these columns, the locomotive inspection department is very reluctant to issue any rules that can in any way hamper the use and development of autogenous welding. At the same time is feels that safety is the first requisite to be looked to. This ballot then is desired as an expression of the untrammeled opinion of railroad officers as to what is proper in the way of the use of autogenous welding in locomotive fireboxes, although it does not touch upon the methods to be used for repair work.

If the ballot is carried in the affirmative, it will mean the establishment of a recommended practice for work done on crownsheets and backhead; while, if it is lost, there will, then, be no governing practice in regard to the matter. For that reason, those voting in the negative have been earnestly requested to give their reasons for the position that they have taken.

Motive Power Condition

Locomotives in need of repair on January 15 totaled 10,736 or 17 per cent of the number on line, according to reports filed by the carriers with the Car Service Division of the American Railway Association.

This was an increase of 967 locomotives compared with the number in need of repair on January 1, at which time there were 9,769 or 15.4 per cent, a decrease of 1,441 locomotives compared with the number in need of repair on January 15, 1925, at which time there were 12,177 or 18.9 per cent.

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Enetred as second-class matter January 15, 1902, at the post office at New York, New York, under the Act of March 3, 1879.

The Water-Tube Boiler

With the advent of the water-tube boiler and the economical results obtained with it in stationary service, it was but natural that attempts should be made to introduce it into marine and locomotive practice. The handicap of the limitations of space and the conditions of operation opposed a formidable obstacle to the extension of its application into these two fields. But in the development of the torpedo boat and torpedo boat chaser it was necessary to have boilers of high steaming capacity in a small space, and so it came about that there were a number of adaptations of the water tube principle that showed a remarkable efficiency in operation. Chief among those achieving success in these lines, were Farrow and Thorneycroft. Although these boilers were in successful operation in marine service they were not adapted to the locomotive. Even in marine work difficulties with the circulation of the water appeared that were unknown in stationary boilers. In some cases designers went so far as to install pumps in order to create an artificial flow of water through the tubes.

When it came to the application to locomotive work, the difficulties assumed another form. The quiet of the setting of the stationary boiler, and the comparatively slight vibration of a vessel, gave place to jars and shocks of such magnitude that it was exceedingly difficult to keep the many joints tight.

This was accentuated in the early water-tube boilers that were put on locomotives by the lack of the means of construction and repair, which we now have; such, for example, as the means of doing autogenous welding.

At any rate the water-tube boiler has not been a success in locomotive work until recently, and that chiefly because of the difficulty of keeping the joints tight.

Then, it is possible, if not probable, that the designers themselves, not being practical railroad men, labored under the difficulty of not knowing exactly what they had to contend with. It is probable that some of the designs that were put on locomotives might have done very well under the quiet conditions of a stationary plant, but when put upon a moving platform that was rolling and plunging about after the manner of a locomotive, and further subjected to the excessive stresses arising from the great differences of temperature existing in their different parts; the fact, emphasized by the good deacon who built the one-hoss shay, that "the weakest part must stand the strain," came most vividly to the front. So we had leakages, high maintenance costs and failure.

These things now seem to be of the past and the record of the boiler illustrated in another column, indicates that there is a prospect of the water-tube boiler coming into its own, and this is probably due, to a great extent, to the fact that its final adjustment to its work was done by men who were thoroughly conversant with the demands and conditions of the service that it has to perform. Evidently its work is satisfactory to the interested departments or it would not be applied on the large scale of ten new locomotives if it was felt by either the operating or mechanical departments that they were incurring any extra risks of road failures or high maintenance charges.

The boilers are still being subjected to critical observation and test, and the final report will be awaited with interest, not only of these, but of other high pressure boilers that are seeking approval.

Autogenous Welding

The chief locomotive inspector of the Interstate Commerce Commission is, apparently very uneasy about the safety of autogenous welding when applied to the making of locomotive firebox repairs. This is evidenced by the repeated warnings that have appeared in his successive annual reports. Year after year he has said that the art is still in an experimental condition and should be used cautiously if at all, and now he asks that such pieces of firebox welding shall be covered and protected by a suitable patch held by bolts, so that, in case the weld does fail, the resulting effects shall be so modified as not to produce a casualty.

His fears are based upon experience, in which he has found that such welding does fail with disastrous results. This year he cited two cases of firebox failures due to low water. In one, where the sheet was riveted, it simply bellied down, pulling off from the staybolts, but doing no more harm. In the other, the sheet having been welded, the weld tore with the usual results.

In short, Washington does not regard the autogenous welding of fireboxes favorably.

On the other hand, at a recent joint meeting of the New York section of the American Welding Society and the Metropolitan section of the American Society of Mechanical Engineers, in a paper on Welded Pressure Vessels, a past president of the Welding Society, made the positive statement that a well made double V autogenous weld was safer and stronger than a rivetted joint; that it could be made stronger than the untouched plate and that, in case of fracture, the break would not occur in the weld. There were no ifs and ands or "I thinks" about it, but an unqualified assertion of fact. It would be noticed, however, that there was a qualifying adjective used, and that is that the weld should be a double V and well made.

Again, we find numerous examples in the construction of new boilers, where the crown-sheet is welded to the side sheets, with never a thought of a weakness developing, and with no record of a weakness having developed, because of the weld, after the boiler had been put into service.

At first blush it would appear that this positive statement of the Welding Society's president, coupled to an almost current practice of the builders, was a complete refutation of the contention of the chief inspector.

There are three things, however, that go far to change this aspect of the case. One is the fact that the interior of a locomotive firebox is a most uncomfortable place in which to work, and the welding of a long crack therein is very fatiguing. A fresh man soon becomes tired at the job and there is a strong probability that his workmanship steadily deteriorates as the job progresses, until, taken as a whole, the weld may fall far short of being "well made."

Then there is the condition of the welded sheet to be considered. It is not free to adjust itself to the varying temperatures to which it is subjected during the process of welding. It is held in place by staybolts in such a manner that injurious internal stresses may be set up, that will facilitate a yielding at the weld.

Finally, in a repair job of this kind it is impossible to make a double V weld. The work, the heating and the building up of the metal must all be done upon one side of the sheet.

As none of these three conditions obtain in the welding of a new firebox sheet, but everything is such that a "well-made" double V weld is possible, that new work can meet the requirements and there is probably no room for an adverse criticism as to its strength.

It would seem well then to try the making of a long weld under the adverse conditions of firebox repairs and then subject it to test. And, in this testing, in order to simulate actual conditions the weld should be subjected not only to a tensile stress but to a bending to and fro in order to imitate, as far as possible, the continual bending and wave-like action to which the sheets of a locomotive firebox are subjected during the whole period in which it is in service either under pressure or in the generation of that pressure.

If this were to be done it is more than likely that the results would be such as to endorse the safety of the welded seam in new boilers; the positive assertion as to the strength of a well-made double V weld and the doubtful security of the single weld made under the conditions of firebox repairing of which the chief inspector is so fearful. It is hardly possible that any of these observers have been mistaken in what they think that they have seen, or in the conclusions that they have drawn from their observations.

A Correction

In the article "The Powerful Three-Cylinder Locomotive of the Southern Pacific Company," that appeared in the January, 1926, issue of Railway and Locomotive Engineering, two errors occurred.

Under the illustration of locomotive 3761 appeared the caption "Three-Cylinder 2-10-2 Type Locomotive of the Southern Pacific Company." The locomotive No. 3761 illustrated is not a three-cylinder locomotive. In the text, the new "Southern Pacific Type," (4-10-2) is referred to as the 2-10-2. The Southern Pacific type has a four-wheel leading truck which is equalized with the drivers.

With the exceptions noted above the other information given was correct.

Action of Draft Gear in Service

To the Editor:

I have read with interest the articles appearing in the Railway and Locomotive Engineering issue of October, 1925, pages 284 to 287, inclusive, entitled "Loss, Damage and Discomfort Due to Improper Handling of Locomotive and Air Brakes." Also page 296, "Draft Gear as a Factor."

The subject matter as to the human element of good judgment and sound principles in train operation of the devices mentioned, is very good and instructive. But the devices themselves that function very well in the laboratory do not hit the mark in train operation.

The air brake does very well considering the length of freight trains and the number of connections that must be made to make it operative throughout the train.

The draft gear is so deficient in stored energy or release that the gears remain in their closed position, which stretches the train line and causes many leaks in air hose couplings that do not exist when the train is standing. This causes many an emergency application of air brakes when a service application only is made. The engineer usually does not know when or why this takes place, but the trainmen at the rear end of the train nurse their sore spots and vent their feelings (by words not fit for print), placing the blame all on the engineer.

Trainmen can be instructed, bulletins may be posted, additional road foremen of engines may be employed, but slack action cannot be reduced by any such methods.

Each draft gear stretches three inches or six inches between each two cars which is low considering lost motion between knuckles, then when the speed of the train reaches say ten miles per hour, and for some reason an emergency application of the brakes is made, the engine will come to a full stop in about fifty feet, the six inches between each two cars must return to its normal position before any cushioning effect of the draft gear is available, and if the gears do not release instantaneously, which many of them do not, then another six inches between each two cars must be added, making twelve inches of movement between each two cars.

Thus it will be readily seen that a train of 100 cars is stretched fifty feet and the engine stops in a space of approximately fifty feet, that the gears must return fifty feet to their normal position before any cushioning effect of the draft gear is available.

The engine of the train will be standing when the rear end is still running ten miles per hour without any cushioning effect from draft gear whatever, as the slack runs in faster than the reduction of air through the train line to apply the brakes.

If the draft gear had sufficient release to hold the gear near the normal position when the engine is working, the gears would be ready to cushion the blow without being forced to get ready before doing the work.

Now, what is draft gear release, or recoil, as commonly expressed by engineers in tests? It is the difference between driving piling into the ground where one expects it to stay which has absorbed a certain number of foot pounds to drive it home, and a spring that is expected to carry a load of a given capacity yielding one way or the other as the force is changed.

For example, one may use the A. R. A. specifications for truck springs, whose Manual states that each group of truck springs for a fifty-ton car shall have a capacity of 78,940 pounds, and as there are four groups in a pair of trucks, the total spring capacity is 315,760 pounds per car, with no mention whatever about recoil, which is the same as the spring capacity. Let anyone mention 300,000

pounds recoil in draft gear for the same fifty-ton car, the cry of "wolf" is so loud that a great many actually believe that real wolves exist.

To satisfy oneself that this awful bugaboo is only imaginary, can easily be proven by actual tests while waiting in the yard before leaving a terminal, by coupling a switch engine to the caboose at the rear end, and applying the engine brake, then go to the head of the train and have the engineer reverse backing the train until the engine stalls. Then make a mark on the rail and a corresponding mark on the pilot beam, lining up with the mark on the rail. Start the engine forward with the same care as though they were ready to leave until the engine stalls again. Now mark the spot on the rail, lining it up with the mark made on the pilot beam; when done, shut off steam, open cylinder cocks so that the engine is free to be drawn back by the stored energy that should exist in the draft gear to bring it back to normal position. Then, if the engine moves back, make the third mark on the rail, corresponding to the mark on the pilot beam when the engine is completely at rest. Then measure the distance between the marks on the railway where the engine stalled in both directions, also the distance the engine was drawn back by the draft gear; if drawn back, note as nearly as possible in miles per hour. Repeat this once a week, and you will have some data really worth while as to the action of draft gears in actual service. "CAR KNOCKER."

We have but one comment to make on the letter from "Car Knocker." Most of the friction draft gears in common use lose efficiency quite rapidly from service or wear and consequently a corresponding effective proportionate part of maximum travel in which they should actually function as "shock absorbers."

Some gears, as a result of heavy impact or blows and existing defects, remain in closed or locked position when driven home. In such instances the particular unit is completely out of commission, with about three inches more or less of slack which in itself is an element of danger in train operation. When several such units are in the same train the dangerous feature which the friction gear is intended to minimize is simply increased far beyond that of the plain helical spring gear. We offer this as a slight digression from the foregoing views of "Car Knocker," and in amplification of the editorial on pages 295 and 296 of the October, 1925, issue. EDS.

Some Features of the Keyser Valley Car Shops of the Lackawanna

W. E. Symons

An inspection of the Keyser Valley car shops of the Delaware, Lackawanna & Western Railroad Company at Scranton, Pa., cannot fail to impress one with their many advantages resulting from:

(a) Physical location of the entire plant.

(b) Arrangement of the different departments or branches of the work in relation to each other.

(c) Systematization of the various kinds and classes of work, including handling raw or unfinished material, machinery for shop operation, and the final fabrication of material into completed units.

(d) Organization and administrative features.

Passing from the superficial to a closer study of the more important features or controlling factors essential to a properly designed and economically operated plant, many contributing items or features are readily apparent on which much could be written, but as space will not permit a complete review with appropriate comments on each factor, the subject of material handling will be particularly emphasized at this time.

Some years ago when it was suggested that the American Society of Mechanical Engineers from a section whose activities be devoted to the question of "handling materials," it was thought by some that the subject was not of sufficient importance to justify its separation from the various other details of engineering and manufacturing of which it was an integral part. Time and its developments, however, have given endorsement to the activities of that section of the American Society of Mechanical Engineers. The economies resulting from improved methods of handling material in a railway shop devoted to

Fig. 1—Electric Lift Truck Approaching Portable Platform Loaded With Lumber

heavy repairs and the construction of new freight cars, is so clearly demonstrated at this plant as to be worthy of special mention.

Electric Lift, Elevating Platform Trucks

Originally, these shops were equipped with a narrow gauge railway system with four wheel lorries for handling material. It was found on investigation, however, that this system was inadequate when all factors were considered, as there was at all times an inflexibility in move-

Fig. 2—Electric Lift Truck and Loaded Platform Under Way

ment of the lorries. When computed in dollars and cents this amounted to no small item, as it was estimated that there was a loss of about 10 per cent in time in the movement of material waiting for the right of way. Quite frequently rivet heaters and cutting torch lorries working on a job would either have to interrupt the work or the material lorries must stand idle for an indefinite period waiting for the right of way.

Then again the four wheel lorry does not always lend itself to expeditious and economical movement of material in the blacksmith and machine shops. Material in the process of fabrication has to be handled as much as 6 or 8 times, while in the carpenter shops there would be an accumulation of lorries loaded with raw stock. This blocked production as it was often necessary to move a number of loaded lorries to make way for another lorry loaded with necessary lumber for some particular job.

There is a loss of time in unloading material from lorries when it is delivered at the point where it is to be used, thus tying up both men and lorries, no small item of cost. With the substitution of the electric lift, elevating platform trucks, a pronounced saving in time and consequent cost of handling material was experienced.

One man with an electric truck will haul eight times the load at three times the speed of a man with a hand truck or 4,000 to 6,000 lbs. on an electric truck as against 500 lbs. on a hand truck at a speed of 350 to 400-ft. per minute instead of the walking pace of 120 ft. per minute, a saving ratio of 24 to 1.

Among the more important advantages of the electric lift truck may be mentioned the following:

1. Increase in shop output, due to increased speed in handling material.
2. Saving time of from 5 to 8 men per unit over present methods now generally employed in handling material.
3. Related economies to other branches of the plant, due to elimination of unadvoidable delays from the use of other and less efficient methods of handling material.
4. Numerous items of time or expense embodied in the net economies resulting from substitution of electric lift trucks.

The illustrations show the electric lift trucks in operation at the Keyser Valley shops.

Fig. 1. Shows electric lift truck approaching one of the bench skids or portable platform with full load of dressed lumber. This platform is 17 inches from the ground.

Fig. 2. Shows this same electric lift truck enroute to point of destination of material, the lift feature having raised the platform from 17 inches to 23½ inches or 6½ inches clearance from floor level.

It is estimated that the saving which can be definitely allocated and credited to the economies resulting from the use of the electric lift truck will equal the first cost or purchase price in one year, and that cost of repairs or upkeep is very low.

It would appear from the foregoing that the officers of the Delaware, Lackawanna & Eastern Railroad, through whose vision and judgement this installation was made, have made no mistake as to methods of increasing output at a reduced cost per unit, and that the available field for improvement in shop facilities of this class is broad and inviting.

Four-Cylinder Locomotives in Europe

The four-cylinder locomotive seems to be regaining its popularity in Europe, and a number have recently been built for the roads of Germany, Austria, Italy and Spain. The accompanying table gives some of the principal dimensions of what may be considered representative engines. Included with them is a three-cylinder simple engine built for the Prussian State Railways. The others are compounds.

It is stated that great difficulty has been encountered in designing such engines to obtain sufficient boiler capacity and yet keep the total weight in working order less than 226,600 lbs. or 103 metric tons. In the accompanying table this appears to have been done in the case of the locomotives for the Baden, Saxony, Italian and Austrian railways. And the conclusion is reached that even these weights could be reduced by about one per cent by a judicious selection of the materials of construction.

In regard to the engines for the Northern of Spain, of which there are several in operation, the boilers have a heating surface of 2489.5 sq. ft. of which the 251.75 sq. ft. in the firebox is obtained by the use of a combustion chamber 35.4 in. long in conjunction with four water tubes that carry the brick arch. The Schmidt superheater, occupying 30 flues, has 899.4 sq. ft. The empty weight

RAILWAY.	Baden	Saxony	Prussian	Italian State	Austrian	Wurtemberg	Northern of Spain
Gauge in.	4 ft.8½ in.	4 ft.8½ in.	4 ft.8½ in.	4 ft.8½ in.	4 ft.8½in.	4 ft.8½in.	5ft.6 in.
No. of Cylindere	4	4	3	4	4	4	4
Cylinder diameter H. P. in.	17.32	18.90	20.37	19.33	17.72	20.08	18.11
" " L. P. in.	26.77	28.35		28.35	29.92	29.92	27.56
Piston Stroke in.	26.77	23.74	25.98	26.77	26.77	25.59	26.77
Driving wheels diameter in.	83.68	76.00	68.90	74.00	57.09	53.15	68.90
Steam pressure, lb. per sq. in.	220	220	206	206	235	220	235
Grate area R sq. ft.	53.79	48.41	43.03	46.26	53.79	45.19	53.79
Heating surface firebox sq. ft.	167.83	166.76	188.27	182.89	187.20	166.76	251.75
" " tubes " "	2250.66	2254.96	2183.96	2366.85	2275.40	2345.33	2237.75
" " boiler H " "	2418.49	2421.72	2372.23	2549.74	2462.60	2512.09	2489.50
" " superheater Hu " "	834.85	796.12	882.19	720.81	635.82	860.67	899.40
" " total " "	3253.34	3217.84	3254.42	3270.55	3108.42	3372.76	3388.90
Ratio H; R	45.0	50.0	55.3	55.0	45.8	55.6	46.6
" H; Hu	2.9	3.04	2.7	3.54	3.88	2.92	2.77
" of cylinder contents	2.39	2.25		2.16	2.85	2.22	2.32
Weight light lbs.	192,500	198,660	220,880	186,120	193,600	216,040	207,460
" adhesive "	117,480	150,920	166,540	145,200	180,400	208,120	142,120
" working order "	213,400	219,780	242,880	204,600	211,200	237,600	229,240
" maximum axle "	39,160	37,840	41,800	35,200	30,014	34,760	35,530
Tractive effort (simple)*	35,890	41,730	41,090	47,335	58,820	72,600	50,900
" " (compound)*	27,385	31,100		34,860	46,955	53,765	38,630
Adhesive Wt.÷Tractive effort(simple)	3.27	3.83	4.05	3.07	3.07	2.87	2.79
" " ÷ " " (compound)	4.29	5.14		4.16	3.84	3.87	3.68

* Calculated by American Locomotive Company's formula

Table Showing the Principal Dimensions of Four Cylinder Locomotives of Europe

of the locomotive is 207,460 lbs. and in working order 229,240 lbs.

Calculations of the tractive effort of these locomotives according to the formulae of the American Locomotive Co., show that the ratio of tractive effort to adhesive weight, when working simple is very low, falling, in two cases, even below 3; while, when working compound, there are three instances where the ratio falls below 4. In one case, that of the Saxony engine, the ratio is higher than usual. These ratios were calculated on the basis of a cut-off at 85 per cent of the strokes which is in accordance with the formula used.

An Early Railroad Stock Certificate

By J. Snowden Bell

The New Castle and Frenchtown Turnpike and Railroad Company, a certificate of the stock of which, issued March 29, 1832, is reproduced in the accompanying illustration, was the outcome of the consolidation of two *turnpike* companies, and was chartered by the States of Maryland and Delaware, respectively, as a turnpike and railroad company, in 1827 and 1829. It extended from New Castle, Delaware, to Frenchtown, on the Elk River, a tributary of Chesapeake Bay, and was 16.4 miles in length. It is stated that it was intended to form "part of the great highway between the cities of Philadelphia and Baltimore." The construction of the road was commenced in August, 1830, and it was opened, with a single track and "turnouts," in February, 1832. It was, for some years thereafter, operated in connection with steamboats between Philadelphia and New Castle, and between Frenchtown and Baltimore, the trip from Philadelphia to Baltimore occupying from 7:00 A. M. to "an early hour in the afternoon," as indefinitely stated in a newspaper advertisement of March, 1834.

The total cost of the New Castle & Frenchtown Railroad (single track) was $376,487.15; estimated cost for second track, $92,047.75; and estimated cost for locomotives and cars, $40,000.00.

In the American Edition of Woods' *"Practical Treatise on Railroads,"* Philadelphia, 1832, the following statement is made as to the first locomotive that was operated on the road.

> "A locomotive engine of the latest pattern made by Robert Stevenson, of Newcastle-upon-Tyne, England), has been imported by the company. The spokes of the wheels are wrought iron *tubes*, bell shaped at their extremities; the rim and hub cast on them—the union being effected by means of borax. The wheels are encircled by a wrought iron *tire* and flange—the latter is very diminutive, and will require enlargement. The weight of the engine is not adapted to a railway of slender proportions, composed of timber and light rails" (page 532).

The weight of the locomotive was 9 tons, of which 6 tons was on the single pair of driving wheels, and it was reported as burning one cord of wood, in passenger service, on a round trip of 33 miles, "inclusive of that burnt in lighting up the fire, and raising the steam, and in waiting upon steamboats." The "slender proportions" of the New Castle & Frenchtown Railroad will appear from the following statement, on page 531 of the same publication:

> "The superstructure is composed of stringpieces of Georgia yellow or pitch pine 6 inches square, on which iron rails 15 feet 4 inches long, 2¼ wide, and 5/8 of an inch thick are fastened by iron nails passing through 12 oblong holes in each bar; beneath the extremities of the latter, iron plates are inserted to prevent sinking. The iron was imported from England."

Stock Certificate of the New Castle and Frenchtown Turnpike & Railroad Company

At the date of the publication, the stock of the Company was quoted at "$37½ for $25 paid."

The seal of the Company which appears on the certificate was adopted by a Resolution of the Board of Directors, May 22, 1830. It bears a representation of the locomotive "Novelty," of Braithwaite and Ericsson, which was operated in the celebrated Rainhill tests, on the Liverpool & Manchester Railway, England. It was subsequently changed by the substitution of a representation of the locomotive "New Castle," which was built in that city.

In 1840, the road was merged into the Philadelphia, Wilmington & Baltimore R. R., by an exchange of stock, and has since been operated as a part of the latter. Since the completion of the Newcastle & Wilmington R. R., the steamboat connections have been discontinued, and the road West of the Delaware Junction disused.

A Good Record on Lubrication and Hot Boxes

Large Increase in Car Mileage and Reduction in Number of Hot Boxes on the Delaware, Lackawanna & Western

Through the kindness of Mr. P. Alquist, master car builder of the Delaware, Lackawanna & Western Railroad Company, we are able to present herewith some interesting figures on the number of hot boxes each month, mileage made and the average number of miles to each hot box, and the total number mileage and average miles per year in both freight and passenger service for the years 1923, 1924 and 1925, on that road.

To all those interested in the question of hot boxes or lubrication, this is a most remarkable showing as it may be noted that the number of hot boxes per month runs as low as only 3, with a car mileage of 1,307,984 miles to one hot box.

The reduction in the number of hot boxes in passenger service was reduced from 205 in 1923 to only 86 in 1925 or more than 56 per cent, while the increased average mileage to each hot box was increased from 209,863 to 535,760, an increase of more than 155 per cent.

In the freight service the total number of hot boxes per year was reduced from 15,465 in 1923 to 6,569 in 1925 or 57.7 per cent, while the average number of miles to each hot box was increased from 19,154 in 1923 to 46,525 in 1925, an increase of 132.4 per cent.

These figures mean much more than they convey to the average reader, but when we consider that hot boxes mean:

(a) Increased fuel consumption.
(b) Delayed trains.
(c) Overtime to engine and train crews.
(d) Extra expense to set out, repair and pick up cars on line, and that this latter item has been estimated at about $20.00 per car, we then begin to realize what this good record means.

If one half the cars with hot boxes in 1923 were set out, which is probably too high an estimate, then at the above estimated cost we would have 7,730 x $20 = $154,600 as the cost to the railway company for hot boxes that year, and by that same token the saving in 1925 would be $76,620 alone, to say nothing of the expense of delayed trains, accidents, wrecks, increased fuel, etc., all of which are closely related to, and not infrequently caused by hot boxes.

There is much food for thought in this display which is most creditable to the head of the department, and those who may have contributed to such satisfactory results.

Passenger Car Hot Boxes and Mileage

	1923 Hot Boxes	1923 Mileage	1923 Average Mileage	1924 Hot Boxes	1924 Mileage	1924 Average Mileage	1925 Hot Boxes	Per cent Reduction Under 1923	1925 Mileage	1925 Average Mileage	Per cent Increase in Mileage Over 1923
January	36	3.350,169	93,060	15	3,599,106	239,934	17	....	3,703,091	217,829	.....
February	28	3,058,722	109,240	13	3,337,774	256,752	17	....	3,402,778	200,163	.....
March	38	3.473,044	88,764	15	3,570,295	238,019	10	....	3,775,967	377,596	.....
April	14	3,386,271	241,876	8	3,569,200	446,150	5	....	3,749,232	749,846	.....
May	10	3,611,442	361,144	9	3,659,596	406,622	3	....	3,752,190	1,250,730	.....
June	17	3,721,738	218,925	5	3,704,978	740,996	5	....	3,866,115	773,223	.....
July	10	3,885,562	388,556	3	3,923.953	1,307,984	4	....	3,984,247	996,061	.....
August	7	3,840,105	548,586	8	3,992 919	499,115	5	....	4,110,889	822,179	.....
September	14	3,650,850	260,775	9	3,850,628	427,848	5	....	4,058,045	811,609	.....
October	12	3,736,057	311,338	4	3,845.128	961,282	8	....	3,909,900	488,737	.....
November	8	3,547,450	443.431	11	3,668,873	333,534	1	....	3,719,332	3,719,332	.....
December	11	3,760,627	341,875	22	3,825,803	173,900	6	....	4,043,578	673,929	.....
Total	205	43,022,037	209.863	122	44,548,253	365,149	86	56.5	46,075,364	535,760	155.0

Freight Car Hot Boxes and Mileage

	1923 Hot Boxes	1923 Mileage	1923 Average Mileage	1924 Hot Boxes	1924 Mileage	1924 Average Mileage	1925 Hot Boxes	Per cent Decrease in Number	1925 Mileage	1925 Average Mileage	Per cent Increase in Mileage
January	1,479	20,175,078	13,641	1,073	23,780,200	22,162	472	....	22,683,402	48,439	.....
February	946	16,950,955	17,918	972	23,765,599	24,450	646	....	24,115,877	37,331	.....
March	1,664	22,421,179	13,474	1,314	27,600,430	21,004	714	....	26,847,561	37,602	.....
April	1,769	24,485,108	13,841	1,242	26,145,905	21,051	456	....	27,106,218	59,443	.....
May	1,858	27,925,625	15,029	936	27,202,795	29,062	473	....	27,305,201	57,728	.....
June	1,372	25,543,388	18,617	608	23,876,497	39,270	511	....	25,850,785	50,588	.....
July	1,345	25,381,361	18,870	686	23,216,777	33,843	414	....	26,057,331	63,133	.....
August	934	24,810,527	26,563	501	23,849,324	47,603	436	....	26,553,595	60,903	.....
September	715	21,031,406	29,414	747	25,734,439	34,450	747	....	22,643,428	46,333	.....
October	1,203	30,126,343	25,042	732	29,719,360	40,600	732	....	26,789,897	36,598	.....
November	1,166	29,952,495	25,602	766	27,559,345	39,578	493	....	24,735,669	50,173	.....
December	1,014	27,425,911	27,047	686	26,369,764	38,440	475	....	24,937,749	52,500	.....
Total	15,465	296,229,375	19,154	10,263	308,820,435	30,090	6,569	57.7	305,626,713	46,525	132.4

Self-Propelled Cars and Locomotives*

Mr. A. H. Candee, General Engineer, Westinghouse Electric & Mfg. Company

We live in an automobile age. There are approximately 21,000,000 licensed vehicles in the United States, of which approximately 17,000,000 are passenger cars. Of course, some of these are electrically driven and some are propelled by steam, but those propelled by the gasoline engine far exceed those propelled by other means. With this stupendous number of gasoline engines operating in all parts of the country you may wonder why there are not more of them applied to the propulsion of rail vehicles.

In the first place, practically all of the intensive development of internal combustion engines for transportation work has been in engine sizes below 100 horsepower for highway vehicles. Lately there have been engines of this type built with 105 or 110 horsepower and there are some being developed which will rate in the neighborhood of 175 horsepower at 1,700 or 1,800 revolutions per minute. Where these higher powered engines are required the production is so small that the price is necessarily high. There have been relatively few engines available for rail car work which have had the requisite power and the stamina necessary for the continuous duty imposed by this class of service. If you consider that one year's service in a rail car with ten hours of service per day and 300 days per year or 3,000 hours of duty is just the same hours of duty that you would get out of your automobile engine if you traveled 6,000 miles per year during a ten year period and your average driving speed was 20 miles per hour, you may see that an engine for rail car work must be of a different character than the ordinary automobile engine.

In the second place, it requires real power to propel a car of the size of a rail car, due largely to the head-end air resistance. A few simple calculations will show this.

Wind resistance $= kSV^2$

$k = .0035$ for flat end car.

$S = 115$ square feet projected area of end of car.

$V =$ Car speed, assumed at 50 miles per hour.

From this you will find that the power required at the wheels to overcome the air resistance alone is 135 horsepower. If you then consider this car maintaining a speed of 50 miles per hour against a head wind of 20 miles per hour you will find that this figure has jumped to 265 horsepower at the wheels. Comparable figures for a passenger automobile having a projected area of approximately 30 square feet would be 35 and 69 horsepower respectively. This indicates that rail car engines must be of relatively large size and explains the marked tendency toward the use of large engines in this class of vehicle.

There is considerable history in the development of the self-propelled rail car, and we are not through yet. As near as can be determined the first steam rail car was brought out in 1847. A compressed air car (storage at 2,500 pounds per square inch) was used on the 2nd Avenue R. R. in New York in 1879. Storage battery cars were use in France in 1885, while gasoline electric and gasoline rail cars were brought out in the nineties. From 1897 on there has been a rather systematic development and in 1901 the first McKeen car was brought out. In 1902 the French Westinghouse Company built about 50 gasoline electric cars for Hungary and a number were built in the United States. Other cars were being developed in the United States about that time.

One of the handicaps which confronted the builders of this type of rail car or locomotive was the gasoline engine. The methods and materials of today were unknown then, yet there are a considerable number of these older types of cars still running and showing satisfactory economies. But the war and the subsequent automotive development and expansion have brought different methods and materials and fuel economies which have been used effectively in the consistent development leading up to the self-propelled rail rar of today.

The demand for rail cars has increased rapidly since the war due to high operating costs, especially of branch lines, and due to the falling off of passenger and freight traffic. This traffic has fallen off largely due to the higher rates of fare and the decrease in operating cost of the privately owned automobile, of the bus, and of the truck. The first attempts to meet this demand for rail cars were made by taking a commercial truck chassis, equipping it with flanged wheels and fitting it with a passenger carrying body. In some cases a light weight four wheel truck was supplied for the front, the two wheels being retained in the rear to permit the application of standard commercial forms of mechanical drive. These were reasonably successful, but they also showed the railroads that a heavier vehicle with greater capacity was required for general service. Thus since 1920 we have seen a gradual increase in car weights and capacities, necessitating larger engines, until now there are standard cars on the market for nearly all classes of service and with engine capacities up to 250 horsepower, capable of hauling a standard railroad coach as a trailer.

The one thing which has been very noticeable in this development is the shrinking market for the smaller cars as the larger cars are brought out. We have been trying to determine the economical limit in engine size for this type of car and it seems that we have just about reached it with the gasoline engine of 250 to 275 horsepower. Larger engines will have some field, but will undoubtedly have to be built on an uneconomical production basis, as the Diesel engine will soon enter the field in the larger capacities.

A brief review of the forms of transmission of power from the engine to the wheels may be of some interest. For light cars and low engine capacities the mechanical transmission is simple and has considerable merit, this mechanical transmission being similar to the standard automotive gear-shifting system. To drive more than one pair of wheels, however, requires some complication, especially on a vehicle which has swivel trucks. This complication has been taken care of very well in several different makes of cars now considered standardized.

In the larger capacity mechanically driven cars gear shifting becomes quite a problem and wear and tear on the gearing is quite a factor. Also, with gear shifting transmissions, when "clutching-in" the engine speed must be relatively low and consequently the power low, so that full horsepower is not available during acceleration. Further, when running at high speed the engine speed is also high with resultant unnecessary wear of the engine.

Hydraulic transmission has been proposed and tried. This has a number of advantages, such as smooth speed changing, engine speed independent of car speed, and ease of control. However, the limitations of this form of drive have not yet been overcome. Among the major limitations at present are leakage and saponification of the oil. This system may have some future, but considerable development must first be carried out.

The electrical transmission is the only satisfactory sys-

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tem for the transmission of real power. Electrical apparatus for railway service has for a background over 35 years of service and development and has been thoroughly tried and proven. A few of the advantages are listed below:

1. Railway motors mounted on the trucks require only cable connections to the car body.
2. Gearing of motors to the axles is simple.
3. Power plant may be located in the most convenient place on the car.
4. Engine speed is independent of the car speed. This means that maximum engine power is available at all times for acceleration or for high speed running, yet when the power required to maintain a given speed is lower than the maximum, the engine speed may be lowered correspondingly. This increases engine life.
5. Simplicity of control.
6. Long life and low maintenance of the transmission as a whole.

The electrical transmission has been criticized by some as having a low efficiency as compared to mechanical forms of drive. We have found, however, that properly designed electrical equipment is not deserving of this criticism; further, that the efficiency does not decrease with increased life, as does the mechanical drive.

Now let us consider the Diesel engine. In the past this type of engine has been large and heavy, and in such a form has not been particularly suitable for rail car purposes. There have been some of these engines operating in Sweden and other parts of Europe for 12 or 13 years in rail car service, but we may assume that if they were an unqualified success that Europe and America would be using these in large quantities, yet there are only about 20 in service. This engine weighs about 70 pounds per horsepower, whereas the modern gasoline engine weighs approximately 15 pounds per horsepower. In general the sizes are also in proportion to the weights. The fuel economy of the Diesel engine, however, makes it the more desirable type.

The development of the Diesel engine until recent years has been chiefly for stationary work and for marine purposes. In the stationary field the prime requisite has been continuity of service and long life. Such engines have been extremely large and of slow speed, weighing from 150 to 300 pounds per horsepower. The marine engine, however, must necessarily be built to conserve space and weight, but where direct-connected to the propeller must be of relatively slow speed. These engines, then, approach railway needs. For the propulsion of rail vehicles weight and space are the prime requisites and the speed of the engine is of secondary importance except as it may affect the space and weight, for in general, the higher the speed the greater the horsepower and the lower the weight and space. In recent years there has been a rather consistent effort on the part of various Diesel engine designers to produce an engine to meet rail propulsion requirements. The most noteworthy of these is the four stroke cycle, solid injection engine built by the Wm. Beardmore & Co., Ltd., of Glasgow, Scotland, and of which there are nine in successful operation on rail cars of the Canadian National Railways. This engine is a modification of an aircraft engine developed by them for the British Admiralty. This engine compares very favorably in size and weight with the modern gasoline engine, as it weighs but 16 pounds per brake horsepower.

It may be assumed that you are all familiar with the principles of operation of the gasoline engine. The Diesel engine, however, is not as generally understood and a brief description of its fundamentals may be of interest to some of you.

Brill-Westinghouse Gasoline-Electric Car in Service on the Reading Railroad

In a four stroke cycle engine, starting with the explosion of the fuel, the piston moves down in the cylinder with the gases of combustion expanding and being transformed into mechanical energy. The return stroke of the piston expels the gases and up to this point the operation is similar to that of the gasoline engine. In the next down stroke of the piston, however, plain air is drawn into the cylinder where in the gasoline engine a fuel mixture is drawn in. On the fourth or upstroke of the piston this air is compressed adiabatically so that its temperature is sufficiently high to ignite vaporized fuel injected into the cylinder. Thus the combustion occurs with the proper injection of the atomized fuel into the cylinder.

The so-called "full Diesel" uses high pressure air for the purposes of fuel injection. This pressure air at 800 to 1,000 pounds pressure per square inch insures proper atomization of the fuel if the injection nozzle is properly designed. The air compressor for this high pressure air, however, involves some complication, and the solid injection system has been developed to introduce atomized fuel into the cylinder without the use of pressure air. In this system the apertures of the nozzle are very small and the fuel is subjected to very high mechanical pressure to vaporize it through the small openings.

In such a development as is now going on it is only natural that engines take varied forms according to the ideas of the designers, and it will probably be years before the economically correct principles are generally accepted and designs standardized as they have been in the gasoline engine. Today there are full Diesels, solid injection engines, and semi-Diesels; there are two-stroke cycle engines and four-stroke cycle engines; there are simple, compound, and double-acting engines; port acavenged engines and engines acavenged through valves in the cylinder head; cylinders in line and "V" engines; vertical cylinders and

horizontal cylinders; single crankshafts and parallel crankshafts. Each individual design has some points of advantage.

We look forward with a great deal of interest to the application of the Diesel type of engine to rail car work. We also expect that engine sizes and weights will continue to decrease until eventually they may be applied to highway vehicles.

You are undoubtedly interested in the economies of the rail car for light passenger traffic or launch line service. The steam train for this service operates at a cost per mile between $0.75 and $1.50 with an average of probably $0.90. Available data indicates that the comparative figures for rail cars using gasoline engines are from $0.25 to $0.45 while Diesel engined cars will operate at figures approximately 25 to 35 per cent lower than the latter. On account of the lack of accurate maintenance data on the Diesel engine time will be required to verify this estimate, although there is every reason to believe that the maintenance of a Diesel engine in railway service should be lower than that of the gasoline engine. In addition to this reduction in operating expense, due to the use of the self-propelled car, there is a reduction of attendant facilities.

One of the problems confronting the railroad executive is the reduction of operating expenses of the "thin" lines. The self-propelled car has proven that it will effectually do this. But why be content with a reduction of expenses alone when it appears that this type of car can be used as a tool to regain some of the traffic now being carried by automobile and bus?

I have had some opportunity of traveling through Iowa, and have talked with a number of local traveling men. I find that they have difficulty in "jumping" from town to town due to limited train service, and are almost forced to the use of their own cars in order to cover their territory thoroughly, even though the actual cost per mile is higher and driving is tiresome and disagreeable, especially in wet or cold weather. An analysis of this problem (admittedly without complete data) would indicate that wider use of the rail car with more frequent service would still permit large reductions in operating expenses and would result in considerable increase in rail travel. To accomplish this effectively, however, will require co-operation of the various railroads, as the desired result would not be attained if only one or two roads were to adopt this policy.

The application of gasoline and Diesel engines to locomotive purposes is in its infancy. As in the rail car, the weight and space requirements of the Diesel engine have limited its application to locomotives where real blocks of power have been required. Gasoline engines have been available for the smaller weights of locomotives and have been used rather extensively in industrial work. For continuous heavy duty, however, the fuel costs have been a severe handicap.

We have recently seen the application of both gasoline and Diesel engines to switching locomotives. The available horsepower per ton of locomotive weight on drivers has been so low that the locomotives are not as serviceable as the steam locomotive but are more in the nature of an experiment, or rather a step in development of the ultimate. Thus, the Ingersoll-Rand Diesel locomotive has 5 horsepower per ton for the 60 ton size and 6 horsepower per ton for the 100 ton size. The Brill-Westinghouse 75 ton switcher, using 500 horsepower in gasoline engines, has 6.66 horsepower per ton. The Baldwin-Westinghouse 1,000 horsepower Diesel has 11 horsepower per ton on drivers. Designs are now underway by various manufacturers for locomotives having as high as 8 to 14 horsepower per ton weight on drivers. An electric locomotive can easily develop 25 to 35 horsepower per ton. Steam locomotives will develop from 18 to 23 or 24. These figures are merely used as a comparison of the "liveliness" of the various types of units. It has been demonstrated in service that the low powered Diesel units with the electrical transmission can develop more than enough tractive effort to slip the wheels and thus can haul immense trains, but this maximum tractive effort limits the speed to a very low value on account of the limited horsepower. As an example, a 60 ton locomotive equipped with a 300 horsepower engine developing 36,000 pounds tractive effort corresponding to 30 per cent adhesion can attain a speed of less than two miles per hour. In order to increase the speed it is necessary to reduce the tractive effort on account of the limited power available. Thus, the time required to switch a given tonnage is relatively high as compared with steam switching.

Locomotive manufacturers have realized the necessity of light weight high speed Diesel engines and have been instrumental in impressing this need on the engine builders. Every pound of unnecessary weight and every extra foot of room required for the engine and transmission means weight in the locomotive structure which might be eliminated. With limited axle loadings this means extra axles in some cases, so that the total locomotive weight may go up much faster than the increase in engine weight and size. The converse is also true to some extent. It may be forecasted that the ultimate switching locomotive will weigh in the neighborhood of 100 tons, all on drivers, and will have at least 1,000 horsepower in engines, while the ultimate passenger or freight locomotive will weigh in the neighborhood of 250 tons, with 80 per cent of this weight on drivers, and equipped with about 3,000 horsepower in engines.

One of the big problems of the self-propelled car or locomotive is that of providing power for the auxiliaries, such as radiator fans, air compressors, battery charging apparatus, and engine starting. Direct connection of fans and compressors to the engine is not often desirable or feasible. With the electrical system of power transmission electrical energy is available for these auxiliaries, but even then the problems are not all solved. In order to use the engine power most efficiently it is necessary to provide for varying the voltage of the main generator which is coupled directly to the engine. The operation of auxiliaries from this varying voltage is not entirely satisfactory. The exciter for the excitation of the main generator is also of varying voltage, this characteristic being inherently necessary for the proper regulation of the engine loading. The solution of this problem in the case of the locomotive seems to be in the provision of an auxiliary generator having constant voltage characteristics, but with the rail car the addition of the third rotating machine is undesirable. As this subject is rather broad and the time limited I will not attempt to go further into the various phases of auxiliary power supply, but have introduced this subject to illustrate some of the problems we have to meet in the application of engines to locomotive or car work.

I do not wish to leave with you the idea that the gasoline or Diesel rail car and the Diesel locomotive are going to supplant the steam locomotive in the immediate future. Undoubtedly the rail car is developed sufficiently at this time to become the economical substitute for the steam locomotive in several classes of service. Locomotives equipped with internal combustion engines, however, have proven their desirability in but one class of service—that of light switching duty. As the ratio of cost between the Diesel locomotive and the steam locomotive is now quite considerable, the railroads will require conclusive demonstrations of the economies of the new form of motive power before they buy in quantities, and it will be many years before the intensely interesting and spectacular steam locomotive vanishes from our sight.

Snap Shots—By the Wanderer

I may be mistaken but it does not seem to me that the public, in general, have ever taken the interest in mechanics and mechanism that the subject deserves. A lecturer on beasts or birds or fishes or flowers, metaphysics or psychology can gather audiences and shekels where a speaker on locomotives or marine engines would talk to empty benches. A machine or an invention must be spectacular in order to attract contemporaneous attention. It is more than probable that Archimedes rushing naked through the streets of Syracuse and shouting, "Eureka," (I have found it) was much more widely commented upon, at the time, than was his discovery of the law of specific gravities which his conduct announced.

This lack of contemporaneous interest in mechanisms is especially marked in the case of the Annual Register. This publication appeared annually in book form from 1758 to 1806, and consisted of volumes ranging from 525 to 1,100 pages in size. Each volume contained a story of the year. That is, there was a history of the year, copies of the principal state papers of the nations of the earth; accounts of the characters of prominent personages; stories of natural history and of antiquities. There were miscellaneous essays, some poetry and book reviews, and a series of articles on "Useful Projects." It contained accounts of two-headed calves; of the Dutch method of curing herrings, and of preserving cabbages, but in the whole series there is not one word regarding the development of the steam engine, except for the bare listing of a patent in the catalogue of the annual output of the British patent office. There is not a reference to the work of Cugnot or Watt or Murdock or Trevethick. Not a lisp about the invention of the condenser and the crank. As far as the Annual Register is concerned there were no steam vessels built by Perrier or Jouffrey or Fitch or Symington. Just nothing doing, to use a bit of slang. Yet here was a development on land and water that was destined to revolutionize the civilization of the world that for nearly fifty years did not get so much as a mention from a great periodical that was supposed to embody the chief and important events of the current time. To say the least, it seems to be passing strange.

We do a little better now, for everything seems to be news for the modern reporter, but the public takes but scant interest in mechanical development, and unless the promoter pays for the display, his work gets a mere mention, while the marriage of an obscure lawyer to his stenographer will get a display heading and pictures galore. Why is it? I don't quite understand it. Do you? Perhaps Carlyle's summary of the character of the people of England three-quarters of a century ago, and Puck's immortal quip can explain it. At least they are plausible explanations.

I had an interesting example of rigid discipline and an equally rigid economy in little things set before me some time ago. It was the case of the power plant of a New England cotton mill. I walked in to the boiler room and the place was as silent as a deserted village. There was not a trace of escaping steam at any of the innumerable joints of the piping. No smoke, no noise, no steam and the fireman in a comfortable chair reading. In the engine room there was a little difference for there was the noise of the click of the Corliss valves and the snap of the main belt at the fly wheel. Spotless cleanliness everywhere, and the engineer doing nothing apparently but reading. The superintendent explained that as every steam leak represented an ever-incrasing lump of coal, and as their coal cost money, they insisted that there be no leaks. They burned Pocahontas coal because, while it was the most expensive per pound of coal, it was the cheapest per pound of steam generated.

The rules were very strict as to the conduct of the men while on duty. They should not read any thing except that which the company provided; but the company would provide any thing in the form of technical literature that the man might ask for. In other words the company required that the men should either be busy at the company's work or should be busy making themselves more proficient in the execution of that work.

Certainly the method seemed to be a success if the cost per horsepower, including the cost of literature, is any criterion, as the figures given me were lower than I thought possible to achieve. The superintendent thought it came because of the stoppage of little leaks.

This was recalled to me quite markedly recently by some locomotive indicator diagrams that were up for examination. They were beautiful cards as far as steam distribution and the arrangement of the valve gear were concerned; but there was a leakage at the ends of the main valves, allowing the steam to blow across and raise the back pressure line, and this little leak was responsible for a loss in the mean effective pressure. If it had not existed the mean effective would have risen about five per cent at starting; nearly six per cent at 16.3 miles per hour and four per cent at 22.5 miles per hour. This probably does not account for all of the steam lost, as there must have been a steady stream into the stack.

Just for the sake of passing the time, let us do a little calculating and assume a loss of five per cent. And five per cent of the steam, while running, would not be far from five per cent of the coal. Let us suppose further that we have a grate with an area of 80 sq. ft. and that, at an average running speed of 20 miles per hour, we are burning 70 lbs. of coal per sq. ft. per hour and that we have a division 140 miles long. That represents a running consumption for the division of 39,200 lbs. of which five per cent or 1,960 lbs. is uselessly burned. Ten engines, in this condition covering the division daily would waste 3,577 tons annually which, at $2.00 per ton, would represent the tidy little loss of $7,154 a year. Quite well worth looking after. We are so apt to forget our old childhood rhyme of, "Little drops of water and little grains of sand . . ." with the other saying about trifles and perfection, when we are looking at or considering little leaks, that the bulking of these little things escape attention. Perhaps we will awaken to their importance some day.

Notes on Domestic Railroads

Locomotives

The Baltimore & Ohio Railroad has placed an order for 25 Santa Fe type locomotives with the Baldwin Locomotive Works.

The Hocking Valley Railway is asking for prices on the repair of from one to 16 Santa Fe type locomotives.

The Gulf, Mobile & Northern Railway has placed an order for 4 Mikado type and 4 Pacific type locomotives with the Baldwin Locomotive Works.

The Potlatch Lumber Company has ordered one 2-6-6-2 type locomotive from the Baldwin Locomotive Works.

The Union Pacific Railroad has placed an order for 9 202-ton three-cylinder, Overland type locomotives, with the American Locomotive Company.

The Mobile & Ohio Railroad has placed an order for 5 Mikado

type and 4 Pacific type locomotives with the Baldwin Locomotive Works.

The New York Central Railroad has placed an order for one 750 h. p. oil-electric locomotive with the American Locomotive Company, The General Electric Company and the Ingersoll-Rand Company.

The Western Pacific Railroad has ordered 5 Mikado type locomotives from the American Locomotive Company.

The New York, New Haven & Hartford Railroad has placed an order for 10 electric locomotives with the American Locomotive Company and the General Electric Company.

The Pennsylvania Railroad has placed an order for 100 locomotive tenders with the Baldwin Locomotive Works.

The Norfolk Southern Railroad has ordered 5 Consolidation type locomotives from the Baldwin Locomotive Works.

The Paulista Railway of Mexico has contracted for 4 switching locomotives with the International Electric Company.

The New York, New Haven & Hartford Railroad has placed an order for 5 electric passenger and 3 electric switching locomotives with the Westinghouse Electric & Mfg. Company and the Baldwin Locomotive Works.

The Illinois Terminal Company has ordered one switching locomotive from the Baldwin Locomotive Works.

The Great Northern Railway has placed an order for 17 locomotive tenders with the American Locomotive Company.

The Florida East Coast Railroad has placed an order for 10 Mountain type and 6 switching locomotives with the American Locomotive Company.

The North River Coal & Wraff Company has ordered one switching type locomotive from the Baldwin Locomotive Works.

The Alberta & Great Waterways Railway has placed an order for one locomotive with the Canadian Locomotive Works.

The Akron, Canton & Youngstown Railroad is inquiring for 2 switching eight-wheel type locomotives.

The Tennessee Coal & Iron Company has ordered 2 switching type locomotives from the Baldwin Locomotive Works.

The Carnegie Steel Company is inquiring for one locomotive tender.

The Lehigh Valley Railroad has placed an order for one 300 horsepower Diesel electric switching locomotive with the McIntosh Seymour Corporation.

Freight Cars

The Chicago & North Western Railway has placed an order with the Pullman Car & Mfg. Co. for 150 ore cars.

The Chicago, Burlington & Quincy Railroad has placed an order with the Pullman Car & Mfg. Co. for 1,000 box cars.

The Pennsylvania Railroad has placed an order with the Carnegie Steel Co. for 100,000 steel car wheels.

The Northwestern Refrigerator Line has placed an order for 325 steel underframes with the American Car & Foundry Co.

The Buffalo & Susquehanna Railroad contemplates putting steel underframes on 200 wooden box cars.

The Nashville, Chattanooga & St. Louis Railway is inquiring for 100 ballast, 75 flat, 100 or more 55-ton hopper and 100 or more 70-ton hopper cars.

The Missouri Pacific Railroad has placed an order for 50 70-ton gondola cars with the Pressed Steel Car Company.

The Seaboard Air Line Railway is inquiring for 1,000 to 1,500 40-ton ventilated box cars and 1,000 to 1,500 gondolas.

The Canadian National Railways plan the repairing of 500 box and dump cars in their own shops.

The Wabash Railway has ordered 10 automobile box cars from the American Car & Foundry Co.

The Northern Pacific Railway has placed an order with the Pullman Car & Mfg. Co. for 150 ore cars.

The Minneapolis, St. Paul & Sault Ste Marie Railroad has placed an order for 500 freight cars with the Pullman Car & Mfg. Co.

The Southern Railway has placed an order with the Lenoir City Car Works to rebuild 1,500 50-ton steel gondola cars. The cars are to be rebuilt with wooden floors and sides and converted into composite cars.

The Wichita Falls & Southern Railroad has placed an order with the American Car & Foundry Co. for 50 40-ton box cars.

The Illinois Central Railroad is inquiring for 2,300 50-ton gondolas, 50 caboose cars, 4 air dump cars and 200 flat bottom gondola cars.

The Atlanta, Birmingham & Atlantic Railway has given a contract for rebuilding 100 flat cars to the Virginia Bridge & Iron Company.

The Chica,o Burlington & Quincy Railroad has ordered 1,000 box cars from the Pullman Car & Mfg. Corporation.

The Chicago & North Western Railway has ordered 250 underframes from the Ryan Car Company. This company has also ordered 225 freight car superstructures from the General American Car Company, 225 from the Illinois Car & Mfg. Co., and 150 ore cars from the Pullman Car & Mfg. Corporation.

The Baltimore & Ohio Railroad has ordered 1,000 hopper cars of 70 tons capacity from the Standard Steel Car Company and 1,000 from the Bethlehem Steel Company.

The American Tar Products Company is inquiring for 50 tank cars of 50 tons and 8,000 gal. capacity.

The Southern Pacific Railroad is inquiring for 1,100 box cars and 500 gondola cars. They will also build 500 gondola cars in their own shops.

The Union Pacific Railroad has awarded the following orders for cars: 500 ballast cars to the Pullman Car & Mfg. Corporation; 500 ballast cars to the American Car & Foundry Company; 700 all steel automobile cars to the General American Tank Car Company, and 300 all-steel automobile cars to the Pennsylvania Car Company.

The Illinois Central Railroad is inquiring for 3,000 or 4,000 miscellaneous freight cars and some passenger equipment.

The Florida East Coast Railway has ordered 40 caboose cars from the Mount Vernon Car Mfg. Company.

The Chicago, Rock Island & Pacific Railway is expected to enter the market for 2,750 miscellaneous freight cars.

The Great Northern Railroad is in the market for 100 automobile cars.

The South African Railways are inquiring through the car builders for 25 high-side gondola cars of 76 tons capacity.

The Anaconda Copper Mining Company has ordered 20 air dump cars from the Magor Car Corporation.

The Chicago, Milwaukee & St. Paul Railway will place orders for repairs to 1,000 to 2,000 stock cars.

The Missouri Pacific Railroad is inquiring for 600 40-ton box car bodies.

The Delaware, Lackawanna & Western Railroad has ordered 25 caboose cars from the Magor Car Corporation.

The Mobile & Ohio Railroad has placed an order for 500 automobile cars with the American Car & Foundry Company.

The New York Central Railroad has ordered 500 automobile box cars of 55 tons capacity from the Standard Steel Car Company.

The Chicago & North Western Railway has ordered 250 steel underframes from the Pressed Steel Car Company, and for 250 general service gondola cars with the American Car & Foundry Company.

The Fruit Growers Express is inquiring for 300 underframes.

The Valley Camp Coal Company is inquiring for from 30 to 40 hopper cars of 70 tons capacity.

The Chicago & North Western Railway has ordered 250 Hart improved ballast and work cars from the Rodger Ballast Car Company.

The Roxana Petroleum Corp. is inquiring for 500 tank cars.

The Reading Company has placed an order for 15 refrigerator cars with the American Car & Foundry Company.

The Jones & Laughlin Steel Company is inquiring for 50 double drop ore cars.

The Allen Garcia Company has placed an order for 90 composite cars with the American Car & Foundry Company.

The Missouri Pacific Railroad is inquiring for 600 double-sheathed box car bodies of 40 tons capacity and repairs to trucks. They are also inquiring for 50 gondola cars of 70 tons capacity.

The Swift Company, Chicago, Ill., are inquiring for 300 underframes for refrigerator cars.

The Kansas City, Mexico & Orient Railway will construct 50 box cars in its own shops.

The Mobile & Ohio Railroad has ordered 500 automobile box cars from the American Car & Foundry Company.

The Chicago & North Western Railway has placed an order for 500 automobile box cars with the Standard Steel Car Company.

The Wabash Railway has ordered 5 steel underframe automobile box cars from the American Car & Foundry Co.

The Great Northern Railway is expected to enter the market soon for 1,000 automobile cars.

The New York, Chicago & St. Louis Railroad has ordered 200 steel freight car underframes from the Pressed Steel Car Company.

The St. Louis Southwestern Railway is inquiring for 26 steel underframes for caboose cars.

The Southern Pacific Company is constructing 500 freight cars in its shops at Sacramento, Calif. This company is also inquiring for 2,000 freight cars.

The Wichita Falls & Southern Railroad has ordered 50 box cars from the American Car & Foundry Company.

The Chicago, Burlington & Quincy Railroad has changed its inquiry from 1,500 box cars to 1,000 box cars.

The Nashville, Chattanooga & St. Louis Railway is inquiring for from 50 to 100 ballast cars and 75 flat cars.

The Illinois Central Railroad has ordered 400 automobile cars from the American Car & Foundry Company and 400 from the Pullman Car & Mfg. Corporation.

The Independent Oil & Gas Company has placed an order for 50 tank cars with the Pennsylvania Tank Car Company.

Passenger Cars

The Atlantic Coast Line Railway has placed an order for 25 coaches, 30 express cars, 10 passenger-baggage, 5 baggage-mail and 2 postal cars with the Pullman Car & Mfg. Corporation.

The Mobile & Ohio Railroad has placed an order for 2 partition coaches, 2 straight coaches and 6 baggage express cars with the American Car & Foundry Company.

The Great Northern Railway has ordered 6 baggage gas-electric motor cars from the Electro-Motive Company.

The Brooklyn-Manhattan Transit Company is inquiring for 201 articulated subway car bodies and trucks.

The Pullman Car & Mfg. Company will build 300 sleeping cars for the Pullman Company.

The Baltimore & Ohio Railroad has ordered 25 coaches and 15 combination baggage and mail cars from the Pullman Car & Manufacturing Corporation; 15 baggage cars from the Bethlehem Shipbuilding Corporation, and 10 horse express cars, 3 postal cars and 5 mail compartment cars from the American Car & Foundry Company.

The Minneapolis, St. Paul & Sault Ste Marie Railroad has placed an order for 2 parlor cars with the Pullman Car & Mfg. Corporation.

The New York, Westchester & Boston Railway contemplates coming into the market soon for 20 multiple unit cars.

The New York, New Haven & Hartford Railroad has placed an order for 12 multiple unit motor cars and 15 trailers with the Osgood Bradley Car Company.

The Duluth, Missabe & Northern has ordered 2 power units for equipping one combination baggage and passenger motor car from the Railway Motors Corporation.

The Union Pacific Railroad has ordered 10 baggage cars, 5 horse-baggage cars and 2 baggage-mail cars from the American Car & Foundry Company, and 15 coach smoking cars, 10 observation cars and 5 dining cars from the Pullman Car & Manufacturing Corporation.

The Duluth & Iron Range has ordered 2 power units for equipping one combination baggage and passenger motor car from the Railway Motors Corporation.

The Chicago & North Western Railway has ordered 3 combination mail-baggage and passenger gas-electric cars from the Electro-Motive Company.

The Union Pacific Railroad has placed an order for 5 dining cars, 10 observation cars, and 15 coaches with the Pullman Car & Mfg. Corporation, and 17 passenger cars with the American Car & Foundry Company.

The Central Railroad of New Jersey is inquiring for 25 coaches, 5 combination passenger and baggage cars and 5 baggage-express cars.

The Central Railroad of New Jersey is inquiring for 25 steel coaches, 5 passenger-baggage and 5 baggage-mail cars.

The Chicago & Alton Railroad has ordered 2 power units for equipping one combination baggage and passenger motor car from the Railway Motors Corporation.

The Nashville, Chattanooga & St. Louis Railway is inquiring for 4 steel passenger and baggage cars.

The New York, New Haven & Hartford Railroad has ordered 12 multiple unit motor cars and 15 multiple unit trailer cars from the Osgood-Bradley Car Company.

The Chicago & North Western Railway has placed an order for 3 mail-baggage-passenger gas-electric motor cars with the Electro-Motive Company.

The Mobile & Ohio Railroad has ordered 6 combination baggage and express cars and 4 coaches from the American Car & Foundry Company.

The Delaware, Lackawanna & Western Railroad has ordered 5 gasoline electric self-propelled passenger coaches.

The Missouri Pacific Railroad has ordered 2 club cars, 3 straight coaches, 3 divided coaches, 2 chair cars, 2 mail and coach cars, 2 steel chair cars, 2 combination coach and baggage cars and 2 combination passenger, baggage and mail cars from the American Car & Foundry Company.

The Baltimore & Ohio Railroad has placed an order for 40 passenger cars with the Pullman Car & Mfg. Corporation, 18 with the American Car & Foundry Company and 15 with the Bethlehem Steel Corporation.

The Chicago, Burlington & Quincy Railroad will rebuild a number of passenger coaches in its own shops. An inquiry has been issued for 25 steel underframes for the first lot to be rebuilt.

The New York, New Haven & Hartford Railroad has ordered 5 gasoline electric self-propelled passenger coaches.

The St. Louis-San Francisco Railway has ordered 2 power units for equipping one combination baggage and passenger motor car from the Railway Sales Corporation.

The Chicago, Burlington & Quincy Railroad has placed an order for 25 steel suburban car underframes with the Bettendorf Car Company.

The Boston & Maine Railroad has ordered three self-propelled gasoline passenger coaches.

The Great Northern Railway has placed an order for 6 baggage gas-electric motor cars with the Electro-Motive Company.

The New York Central Railroad has placed a contract to install Diesel oil-electric equipment on one combination passenger and baggage car for experimental purposes.

The Delaware, Lackawanna & Western Railroad has placed an order for 25 caboose cars with the Magor Car Company.

Buildings and Structures

The Southern Pacific Company purchased a new site south of Fresno, Calif., and will spend approximately $2,000,000 in new switching and classification yards and shop facilities.

The Baltimore & Ohio Railroad has asked for revised bids for the construction of a coaling station at Mitchell, Ind.

The Wabash Railway plans the construction of a one-story brick and steel extension to its locomotive shop at Decatur, Ill., to cost approximately $500,000.

The New York Central Railroad has awarded a contract to the Cleveland Crane & Engineering Company, New York, for the manufacture and erection of an electric traveling Gantry crane at its Thirtieth street, New York, yard at a cost of approximately $27,000.

The Fort Dodge, Des Moines & Southern Railroad is building a 30,000 gallon steel water tank, to cost $10,000 at Fraser, Iowa.

The Southern Railway has placed a contract with J. M. Dunn & Sons, Knoxville, Tenn., for rebuilding planing mill at Knoxville, Tenn.

The Missouri Pacific Railroad jointly with the Texas-Pacific contemplates the rearrangement and enlargement of joint track facilities at Texarkana. They planned for construction this year as follows: 350 ton mechanical coaling station at Washington, Mo., to cost approximately $50,000, also for 250 ton mechanical coaling stations at Centerview and Archer, Mo., to cost approximately $40,000 each.

The Illinois Central Railroad plans immediate rebuilding of its car repair shop at Harshan near New Orleans, which was damaged by fire on January 1 with a loss of $150,000.

The Norfolk & Western Railway has placed a contract covering buildings and shop facilities at Williamson, W. Va.

The Canadian National Railways will convert their locomotive shops at Toronto into a steel car repair shop.

The Denver & Rio Grande Western Railroad is reported to be planning the construction of an addition to its machine shops at Denver, Colo.

The Southern Pacific Company plans remodeling and building additions to its passenger station at Riverside, Calif.

The Great Northern Railway Company plans remodeling its roundhouse at Hillyard, Wash., at a cost of $50,000.

The Central of Georgia Railway Company is asking for bids for the construction of a nine-stall roundhouse, a storehouse, a boiler room and a lavatory at Albany, Ga.

The Pennsylvania Railroad has awarded a contract for the extension and erecting of machine shops at Olean, New York, at a cost of approximately $100,000.

The Central of Georgia Railway plans the construction of a one-story concrete, brick and steel engine house at Albany, Ga.

The Pennsylvania Railroad Co. has awarded a contract for filling in in connection with its new $2,200,000 produce yard to be constructed at Delaware Avenue and Packer Street, Philadelphia, Pa.

The Chicago & North Western Railway plans the construction of a water softener plant at Norfolk, Nebr., with a capacity of 125,000 gallons to cost approximately $20,000.

The Pittsburgh & Lake Erie Railroad has placed a contract for a one-story repair shop at Newell, Pa.

The Chesapeake & Ohio Railway has placed contracts for a water station at Stevens, Ky., with the Graver Corp., the Railroad Water & Coal Handling Co., and the Fairbanks Morse Company.

The Baltimore & Ohio Railroad is reported to be planning extensions to its car and locomotive repair shops at Cumberland, Md., to cost approximately $200,000.

The Boston & Maine Railroad has placed a contract covering the construction of coal distributing plant at Mystic Wharf, which will cost $450,000.

The Southern Pacific Company has awarded a contract for the construction of a subway under the tracks of the Southern Pacific

and the Western Pacific at Miner Avenue, Stockton, to cost approximately $100,000.

The Pennsylvania Railroad has awarded a contract to the American Bridge Company, New York, for the fabrication and erection of a steel superstructure for extension of the tank shop at Olean, New York, to cost $225,000.

The Chicago, Burlington & Quincy Railroad is drawing plans for an addition to its engine house and repair shops at South Sioux City, Nebr.

The Cleveland, Cincinnati, Chicago & St. Louis Railway are preparing plans for the construction of an extension to the engine terminal facilities at Kankakee, Ill., to cost approximately $253,000.

The Southern Railway plans the construction of plant for icing refrigerator cars at Chattanooga, Tenn. This is included in the $1,100,000 yard improvements.

The Reading Company plans a railroad terminal with station and yards at Trenton Junction, New Jersey.

Items of Personal Interest

P. W. Kiefer, engineer of rolling stock of the New York Central Railroad, has been appointed chief engineer of motive power and rolling stock, succeeding **F. H. Hardin**, promoted to assistant to the president. **E. P. Moses**, general equipment inspector of rolling stock, has been appointed engineer of rolling stock, succeeding **P. W. Kiefer.**

Charles E. Barba has been appointed mechanical engineer of the Boston & Maine Railroad, with headquarters at Boston, Mass., succeeding **Carl B. Smith**, who has been appointed assistant to the mechanical superintendent, with the same headquarters.

J. C. Murray, vice-president and general manager of the Missouri & North Arkansas Railway, with headquarters at Harrison, Ark., has resigned.

W. G. Curren, general superintendent of transportation of the Baltimore & Ohio Railroad, with headquarters at Baltimore, Md., has been appointed general manager, with headquarters at New York, N. Y., succeeding **R. B. White**, who has been elected senior vice-president of the Central Railroad of New Jersey.

A. B. Ford has been appointed general master mechanic of the Great Northern Railway, with headquarters at Superior, Wis., succeeding **T. E. Cannon**, retired.

C. W. Y. Currie, managing editor of the New York Central Lines Magazine, is appointed also assistant publicity manager of the New York Central Lines, with headquarters at New York City.

Theron O. Jennings, assistant to the president of the Chicago & Eastern Illinois Railway, with headquarters at Chicago, Ill., has resigned to become general coal agent of the Chicago, Rock Island & Pacific Railway, with headquarters at Chicago, Ill.

H. C. James has been appointed assistant to general superintendent of the Northern Pacific Railway, with headquarters at Seattle, Wash., succeeding **L. F. Newton. W. C. Showalter** has been appointed superintendent of the Tacoma division, with headquarters at Tacoma, Wash., succeeding **W. C. Albee. James Shannon** has been appointed superintendent of the Idaho division, with headquarters at Spokane, Wash., succeeding W. C. Showalter. **L. F. Newton** has been appointed to superintendent of the Pasco division, with headquarters at Pasco, Wash., succeeding James Shannon.

A. B. Chapman has been appointed supervisor of welding for the Chesapeake & Ohio Railway, with headquarters at Huntington, W. Va.

Donald Barrett has been appointed assistant engineer of the Wisconsin division of the Chicago North Western Railway, with headquarters at Chicago, Ill.

D. T. Waring has been appointed assistant to the vice-president of the Susquehanna & New York Railroad, with headquarters at New York, N. Y.

E. F. Rummell, division superintendent of the Chicago, Milwaukee & St. Paul Railway, with headquarters at Spokane, Wash., has been promoted to general superintendent, with headquarters at Butte, Mont.

J. A. Appleton has been appointed superintendent of the Ashtabula division of the Pennsylvania Railroad, with headquarters at New Castle, Pa. **Ralph C. Miller** was also appointed superintendent of the Schuylkill division, with headquarters at Reading, Pa.

W. R. Meeder has been appointed superintendent of motive power of the Missouri & North Arkansas Railway, with headquarters at Harrison, Ark.

The title of **C. H. Terrell**, assistant superintendent of motive power of the Chesapeake & Ohio Railway, has been changed.

Edwin P. Moses has been appointed engineer of rolling stock of the New York Central Railroad, with headquarters at New York City.

C. W. Van Horn has been appointed general superintendent of transportation of the Baltimore & Ohio Railroad, with headquarters at Baltimore, Md.

Roy B. White, formerly general manager of the Baltimore & Ohio Railroad, has been elected senior vice-president of the Central Railroad of New Jersey, with headquarters at New York, N. Y. **Charles H. Stein** has been appointed assistant to Mr. White, with the same headquarters.

F. C. Paulson, division engineer of the Wyoming division of the Union Pacific Railroad, with headquarters at Cheyenne, Wyo., has been appointed assistant superintendent of the Wyoming division, with the same headquarters, succeeding **H. A. Connett**, who has been appointed superintendent of the Western division, with headquarters at Green River, Wyo.

F. H. Hardin has been appointed assistant to the president of the New York Central Railroad, with headquarters at New York, N. Y.

W. D. Freeman has been appointed master mechanic of the North Carolina division of the Seaboard Air Line, with headquarters at Hamlet, N. C., succeeding **T. J. Raycroft**, resigned. **J. J. Hanlin** has been appointed master mechanic of the Georgia division, with headquarters at Atlanta (Howells), Ga., succeeding **G. W. Gilleland**, who has been appointed superintendent of motive power of the Central and Southern districts, with headquarters at Jacksonville, Fla., succeeding Mr. Hanlin.

Supply Trade Notes

G. N. DeGuire has been appointed assistant to the president, **Locomotive Firebox Company.** Mr. DeGuire was born in Appleton, Wis., March 31, 1884, and was educated in the schools of that city. He entered the service of the Chicago & North Western Railway as locomotive fireman in 1902 and was promoted to engineer in 1906, and for ten years thereafter served as engineman with the exception of three years spent in the study of locomotive and car construction and shop, enginehouse and railroad operation in general, in various parts of the United States. He received a civil service appointment as inspector of locomotives with the Interstate Commerce Commission in 1916 and on January 1, 1918, he resigned to enter the service of the United States railroad administration as supervisor of railroad equipment. On June 1, 1918, he was promoted to general supervisor of equipment for all lines east of Chicago, and on February 1, 1919, was given jurisdiction, in the same capacity, over all lines under federal control in the United States. At the termination of federal control Mr. DeGuire was appointed assistant manager, department of equipment, division of liquidation claims of the United States railroad administration, and on July 1, 1923, was promoted to the position of manager of this department, which position he held until the work was concluded. Mr. DeGuire has been in New York handling financial matters during the past two years. He has just resigned his position as president of the Premier Guarantee Mortgage Bond Corp., to become assistant to the president of the Locomotive Firebox Company.

The Standard Steel Car Company has secured the interests of the **Columbia Steel Company**, and the plant will be combined with the **Forged Steel Wheel Company**, at Butler, Ohio.

The International Motor Company, manufacturers of Mack trucks and buses, has purchased the **Niles-Bement-Pond Company** plant, located at Plainfield, N. J., as part of its expansion program. The plant will be occupied by the International Motor Company's General Service Department, now located at New Brunswick, N. J.

The Graybar Electric Company has been formed with a capitalization of $15,000,000 to succeed the supply department of the **Western Electric Company.** The new company's stock is owned by the Western Electric Company.

T. M. Girsler, general manager of the **Jones & Laughlin Steel Corporation**, Pittsburgh, Pa., has been elected a director and vice-president in charge of operations of that company.

J. H. Redhead, formerly assistant to vice-president and assistant manager of sales of the **National Malleable & Steel Casting Company**, has been elected vice-president and general manager of the **Columbus Malleable Iron Company**, with headquarters at Columbus, Ohio.

The Ludlum Steel Company is making many additions to its plant at Watervliet, New York. The capacity of the Billet grinding department has been doubled due to increased business.

Robert H. Dibble has been appointed metallurgical engineer of the **American Sheet & Tin Plate Company**, and **William C. Tamplin** has been appointed assistant to the vice-president.

F. C. Horner has been appointed assistant to vice-president of the **General Motors Corporation,** with headquarters at New York and will be in charge of the development of the commercial motor vehicle field on steam and electric railroads.

K. E. Keiling, who has served for a number of years in the office of the purchasing department of the New York Central Railroad, has been appointed purchasing agent of the **New York Air Brake Company,** with headquarters at New York, succeeding **W. R. Brown.** B. J. Minnier, vice-president in charge of production at Watertown, N. Y., has resigned.

R. M. Chisson, representative of the **Lehon Company,** with headquarters at Chicago, has resigned to become manager of railway sales of the **Otley Paint Manufacturing Company,** Chicago, Ill.

C. D. Foltz, representative of the **Westinghouse Air Brake Company,** in charge of the Denver and Salt Lake City offices, has been appointed assistant western manager, with headquarters at Chicago.

The Morton Manufacturing Company has just purchased property adjacent to its present Chicago plant, on which it is planning the construction of an addition, which will provide 50,000 square feet of additional shop space.

Andrew F. McCoole, with office at Railway Exchange Building, St. Louis, Mo., has been appointed railway representative in that territory of the **Murphy Varnish Company,** succeeding **J. K. Milligan,** resigned.

Joseph C. McCune, engineer of the Eastern district of the **Westinghouse Air Brake Company** has been appointed assistant director of engineering, with headquarters at Wilmerding, Pa.

J. Howard Horn, sales manager of the **National Lock Washer Company,** has been elected general sales manager, with headquarters at Newark, N. J.

The Unicn Switch & Signal Company has placed a general contract for a one-story forge and machine shop addition at a cost of $45,000.

The Paige & Jones Chemical Company has purchased property adjoining their plant at Hammond, Ind., and will add to their present plant capacity.

George H. Charls has been elected president of the **United Alloy Steel Corporation** to succeed **E. A. Langenbach,** who has been elected chairman of the board. **L. G. Pritz,** vice-president in charge of operations, will succeed Mr. Charls.

Thomas S. Stephens has been appointed manager of railway sales of the machinery department of the **Manning, Maxwell & Moore, Inc.**

S. J. Nicholson has been appointed acting vice-president of the **Westinghouse Electric & Manufacturing Company.**

G. L. Hulben has been added to the sales force of the **Ludlum Steel Company** of Watervliet, N. Y., and will have his headquarters in Chicago, Ill.

F. O. Paul has been appointed service manager of the automotive car division of the **J. G. Brill Company,** Philadelphia, Pa.

C. H. Lang has been appointed comptroller of budget of the **General Electric Company.** Mr. Lang was formerly assistant manager of the publicity department.

The Buda Company has opened an office in Jacksonville, Fla., to be in charge of **A. L. Bliss,** formerly of their Chicago office.

M. A. Herald has resigned as sales representative of the **Standard Tank Car Company,** and has organized the **United Car & Equipment Company,** with office in the Westinghouse building, Pittsburgh, Pa.

Albert Lincoln Salt has been elected president of the **Graybar Electric Company,** taking over the business of **Western Electric Company** electrical supply department. The Graybar Electric Company is a modified form of the partnership name of Gray & Barton, the original designation of the company founded in 1869. Mr. Salt began his business career in 1881 as a temporary office boy in the New York office of the Western Electric Manufacturing Company which later became the Western Electric Company. **Frank A. Ketcham** has been appointed executive vice-president of the Graybar Electric Company, formerly the supply department of the Western Electric Company. He became general sales manager of the Western Electric Company in 1918, less than twenty years after he began working for the company as a clerk in its Chicago office. In 1923 he was appointed general manager of the supply department which had been separated from the telephone department in 1921, which position he held until his present appointment as executive vice-president. He was born at Saginaw, Mich., and attended the University of Michigan. **Leo M. Dunn** is also a vice-president of the new company in charge of merchandising and accounting as well as **George E. Cullinan,** who has charge of sales. **Elmer W. Shepard** is treasurer and N. R. Frame, secretary.

G. A. Secor, general storekeeper of the Chicago & Alton Railroad, has resigned to become sales representative of the **Buda Company,** with headquarters at Chicago, Ill., and **R. M. Blackburn,** formerly general storekeeper of the Chicago & North Western, has been appointed representative of the Buda Company, with headquarters at Chicago, Ill.

Joseph C. McCune, who has been connected with the **Westinghouse Air Brake Company** in various engineering capacities since 1913, and who enjoys a very wide acquaintance in railroad and engineering circles, has been appointed Assistant Director of Engineering with the Air Brake organization, in keeping with the traditional policy of that company in advancing men that have developed in its own ranks of employees.

Mr. McCune was born in Brilliant, Ohio. After two years preparatory studies at Washington and Jefferson University, he entered Cornell where he won the first Sibley prize for scholarship, graduating in mechanical engineering with the class of 1911. He obtained his first employment with the Cutler Hammer Company at Milwaukee, later became connected with the street railway traction system of the Pittsburgh Railways Company, and from there entered the Air Brake organization at Wilmerding as assistant to the chief engineer. From 1915 to 1917 he served as mechanical expert for the company in the Eastern district, with headquarters at New York. For the next two years he served his country on the Mexican border with the 7th regiment, New York National Guards, and later in the World War as First Lieutenant of Engineers of the United States Army, with ten months' service in France. At the conclusion of the latter he was made special engineer of the Engineering Department at Wilmerding, in which capacity he remained for several months. He was then again transferred to the Eastern district, where he served first as assistant to the district engineer and then as district engineer. He held this position until his recent appointment, which will again bring him to the home office of the Air Brake Company at Wilmerding.

C. D. Foltz, who, as representative of the **Westinghouse Air Brake Company** in charge of the Denver and Salt Lake City offices, is well known to railroad men throughout the middle west, has been appointed assistant western manager of the Air Brake Company, making his headquarters hereafter at Chicago.

Mr. Foltz has been connected with the railroad business for many years. At the age of fifteen years only he was already a telegraph operator on the Wabash. Later, he was a fireman on the Chicago, Milwaukee & St. Paul, from which post he became an engineer on the Union Pacific, Denver & Gulf Railroad. He was also engineer on the Santa Fe Railroad, running an engine between Denver and Pueblo for eight years, after which he was promoted to the position of traveling engineer.

He entered the service of the Westinghouse Company in 1910 as inspector in Salt Lake City and was afterwards promoted to mechanical expert and representative at that office, from which position his field of activity was widened by the inclusion of the Denver office. His headquarters were moved from Salt Lake City to Denver in 1923, and he has remained there until his recent advancement.

G. E. Brown, general foreman electrician of the Northern Pacific Railway, has resigned to go with the **Westinghouse Electric & Manufacturing Company,** as salesman in the transportation department, with headquarters at Minneapolis, Minn., succeeding **R. F. Castner,** who has been appointed manager of the Des Moines branch, with headquarters at Des Moines, Iowa.

LeGrand Parish has retired as president of the **American Arch Company,** New York, and has been succeeded by **H. B. Slaybaugh,** who has been executive vice-president of the company and has been associated with Mr. Parish throughout the life of the company **George A. Price,** treasurer has been made secretary and treasurer; **F. B. Johnson** has been made assistant secretary and **H. W. Muller** has been made assistant treasurer, all with headquarters at New York.

New Publications

Air Brake Catechism. By Robert H. Blackall. Revised and enlarged by F. H. Parke. New York, The Norman W. Henley Publishing Co. 707 pages, 5 in. by 7½ in. 279 Illustrations. 2250 Questions and answers.

On the title page the statement is made that this is the most practical and complete work published on the subject and the statement is undoubtedly true.

A number of years ago an engineer of the Westinghouse Air Brake Co. was asked as to whether there was anyone connected with that company who knew all about the air

brake. After a moment's hesitation he said that he thought that Mr. Turner did. But Mr. Turner is dead, and he seems to have bequeathed a large share of his knowledge of the air brake to Mr. Parke, who is an engineer with the Westinghouse Air Brake Co. At least, he evidently knows so much about air brakes that it does not seem as though there could be much more to know, and this knowledge he has set down, for the most part, in such simple, concise language that it is readily understood by the veriest layman. There are points, however, where, knowing as much as he does about the subject he has evidently taken it for granted that the reader, too, is an expert. It is suggested that it would have been adviseable to have submitted the manuscript to some engineer, who was not an air brake expert, so that he could have pointed out places that are not perfectly clear, and picked out little omissions of reference figures and letters in the illustrations that would have straightened out puzzling descriptions.

The book is called an "up-to-date" catechism and it probably was when the manuscript was sent to the printer. The same appellation was given to Mr. Blackall's catechism that bore the imprint of 1898. That, too, was set forth as a complete study of air brake equipment, and contained a thousand questions that were included in 230 pages.

There is enough in the early part and scattered through the book to warrant the expression, "revied and enlarged," but "re-written" would state the case more correctly, for this work is practically a new book that has been worked out with great care and thoroughness.

After a few desultory questions about brakes in general, it takes up the old plain triple valve that could be used interchangeably with straight air. Then comes a discussion of the quick action brake with its peculiarities and troubles leading up to the K-triple to which ten pages are devoted. This was the last word in triple valves in its day, but in 1908 the L valve was developed for passenger service. The descriptions of these valves embody their methods of operation so that their intricacies are readily understood except in a few instances where the author has presumed too much on the knowledge of the reader.

The chapter on Westinghouse Freight Equipment deals with the air brake portion and does not touch the foundation rigging which is fully dealt with in a succeeding chapter. The heading of the chapter is exclusive, for had it not been limited to Westinghouse equipment it might have been permissible to describe some outside equipment, slack adjusters, for example, that are extensively used. But, then, the whole book is exclusively and solely Westinghouse with the exception of a reference to water brakes.

The compressors, brake valves, main reservoirs and the old high-speed brake then come in, followed by an exhaustive treatment of the E T engine equipment and everything pertaining to the engine. After which we have two chapters dealing with the intricate complexities of the P C and U C equipments. Mechanisms that will require the closest attention and study to understand and which really call for more elaboration than could be given here, if all of the intricacies were to be set forth.

Besides the steam railway equipment, the book goes into the subjects of electric locomotive, and electro-pneumatic equipments just touching upon some outside matters such as the water brake.

There is a chapter on braking leverage and one on inspection and train handling. The latter contains a deal of excellent suggestions that should be fixed in the minds of all engineers, for it all tends to safe and conservative operation. Some may even think it too conservative, as when it recommends that brakes should not be released on freight trains at speeds of less than twelve or fourteen miles per hour, when common practice places it at not much more than half of that.

In short, a most excellent and valuable book, but with one fly of considerable magnitude in the ointment, and that is the engravings. These are frequently evident photo reductions from larger prints, and in making them the lettering has become so small as to be almost illegible. That and the occasional lapse of the author into incomplete descriptions are the sole adverse criticisms that can be made.

First Railroad Into Washington and Its Three Depots. By Washington Topham, Columbia Historical Society, Washington, D. C. 247 pages. 6 in. by 9 in. Six illustrations. Paper.

This book is a reprint of a paper that was read before the Columbia Historical Society, and is a record of the properties occupied and the transactions involved in the building of the Baltimore & Ohio Railroad into Washington in 1835 with some of the subsequent developments.

While the text follows a general chronological order in its presentation it frequently doubles back on its tracks and repeats what has already been stated.

The book contains excerpts from previous publications dealing with the owners and occupants of the property upon which the original station was located, and rather elaborate descriptions, taken from the press of the day of the opening of the road into Washington from Baltimore with an account of the running of the first train. There are numerous anecdotes connected with the road such as the visit of Baltimore troops to Washington and the celebrated race between Peter Cooper's locomotive, the Tom Thumb, and the old gray horse.

There is nothing, however, descriptive of any of the engines used with the exception of their names and a reference to the diminutive grasshopper engines used to haul the first trains. There are a number of side issues intercalated in the text, and the whole is a collection of statements of facts connected with the road.

The present Union Station is handled at the end in about two pages and a half. Too short a space in which to give a description of the station. The account is limited to brief statements as to cost, contractors and the occupation of the properties.

It is a record of isolated items without any attempt to tie them together in a consecutive narrative.

Railway and Locomotive Engineering

A Practical Journal of Motive Power, Rolling Stock and Appliances

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Three-Cylinder Locomotive for the Southern Pacific Ry.

A Description of Some of the Details of Especial Interest

Considerable data regarding the three-cylinder locomotives, built for the Southern Pacific Ry. by the American Locomotive Co. have been published in Railway and Locomotive Engineering in the issues of March, September 1925 and January 1926. In the latter issue a mistake was made to which attention should be called. The engines were there referred to as being of the 2-10-2 class when it should have been 4-10-2, with this exception the information given is correct.

Three-Cylinder 4-10-2 Type Locomotive of the Southern Pacific Railway

What follows is a description of a number of the details of construction of these engines in which are embodied some special design or novelty:

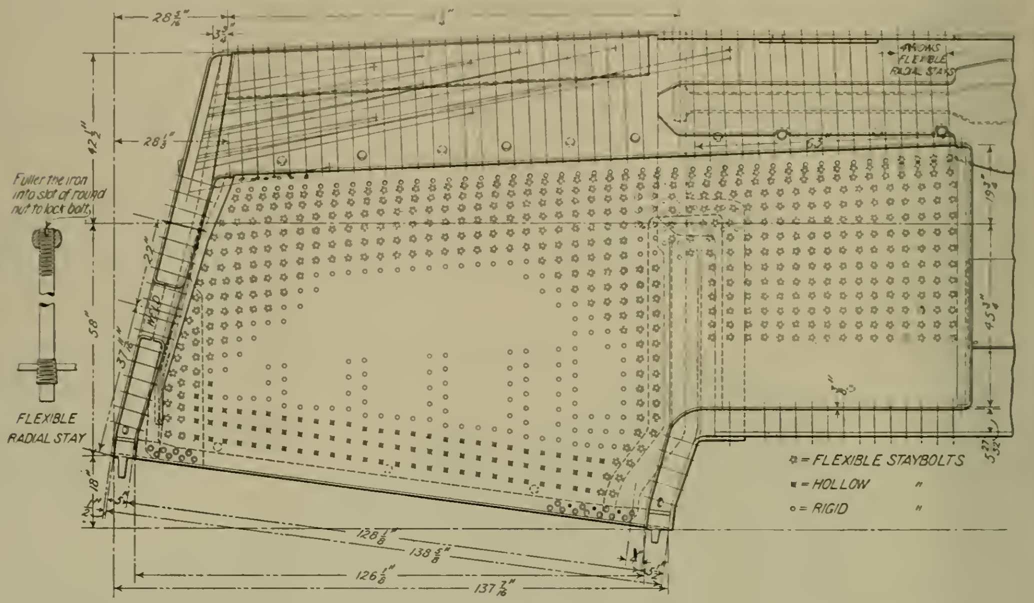
The Boiler

The boiler is of the straight top type with an outside diameter of 90⅛ inches at the front barrel course, increasing to 100 inches at the combustion chamber course. The firebox measures 127¼ inches by 102¼ inches inside of the sheets at the mud ring, and includes a combustion chamber of 74 inches in length, which provides for tubes 23 feet 6 inches long. The steam space above the crown sheet is 30⅛ inches at the back end and 25 29/32 inches at the front end. The Type "A" Superheater which is used consists of 50 units with a super-heating surface of 1,500 square feet. The boiler shell is of 29/32 inch material for the first course, 31/32 inch for the second course, and 1 inch for the third course; and the wrapper sheet is ½ inch thick, reinforced at critical points at the top and a portion of the way down the sides with a 5/16 inch liner, to give the required strength. The firebox and combustion chamber sheets are ⅜ inch thick, excepting the inside throat connection which is ½ inch thick, and welded in between the side sheets and the combustion chamber. The firebox is fitted with the Flannery Bolt

Co's. welded universal sleeves and reduced body staybolts. The boiler bracing throughout is the American Locomotive Company's weldless type, which provides for a maximum strength with minimum weight. The boiler is secured to the frames at the firebox with the expansion plates rather than with cast steel furnace bearers having the ordinary sliding shoe. This avoids the trouble usually experienced with this latter type of furnace bearer support.

The boiler contains 261 tubes $2\frac{1}{4}$ inches in diameter the throat sheet and increased to six in the back head, besides being carried, in a single row about the door opening. The back head is also fitted with two rows of flexible stays at each side, extending from the crownsheet to the foundation ring.

Attention is called thus extensively to the method of firebox staying, because of the great dimensions of the firebox and combustion chamber and the long tubes that are used. The distance from the back head to the back tubesheet is 15 feet $3\frac{1}{4}$ inches to which must be added



Firebox of Three-Cylinder Locomotive of the Southern Pacific Showing Method of Staying Employed

and 50 flues of $5\frac{1}{2}$ inches diameter for the superheater units.

The Tate flexible staybolt is used extensively throughout the firebox and combustion chamber. The distribution in the firebox includes the six upper horizontal rows with a filling in of the back upper corner and a straggling down to the foundation ring in the two back rows. At the front there is another slight filling in of the upper corner with two rows back of the combustion chamber that extend down to the foundation ring.

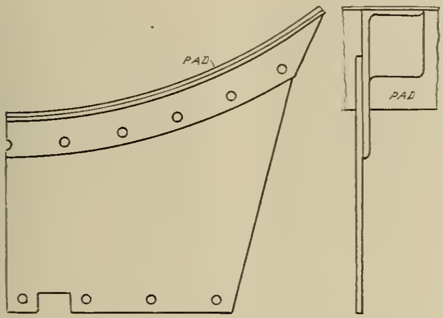
The sides and bottom of the combustion chamber are stayed with a complete installation of the Tate flexible bolts, but the top, which is flattened and conforms in general contour to that of the crownsheet is stayed by the ordinary rigid bolt, except for the four front rows, which are flexible and are expected to act like the ordinary sling stays. Owing to the bottom of the combustion chamber being fitted with flexible bolts with the consequent freedom of motion afforded thereby, it is doubtful whether there is any real necessity for these flexible sling stays, and whether their action is essentially different from what rigid stays would be, except for their backward yielding under the thrust of the tubes, by which the point of rigid support is moved back but not removed.

At the bottom of the firebox at the sides there are three rows of hollow staybolts, which are cut down to one in the 23 feet 6 inches length of tube, all of which is exposed to the direct action of the fire. It is evident that at times there must be a considerable difference between the expansion of the outer shell and these surfaces exposed to the fire. That such a difference does occur was shown to be the fact by an investigation that was described in some detail in Railway and Locomotive Engineering for November, 1919, in which it was shown that there was no such thing as a neutral zone, where there was no movement of the staybolts; but that every bolt in the sidesheets was in constant motion from the time of lighting the fire until the boiler was again cold. As the investigation, referred to was made on a much smaller boiler than the one here illustrated, the distance from the back head to the back tubesheet being only 8 feet $8\frac{1}{2}$ inches, it is evident that the relative movements of two sheets of the firebox would be much less than in this boiler, hence the necessity for the extensive use of flexible staybolts that is here employed.

Reference has been made to the method of supporting the boiler. Located between the cylinder connection to the boiler and the front furnace bearer, and to the rear of the third pair of drivers, is a waist bearer sheet securing the frames to the boiler, for the purpose of providing suitable support for frame at this point when locomotive is lifted in the shop by a crane. The connection of the waist sheet

to the boiler is of an improved design, whereby the angle iron is riveted to a pad which, in turn, is stagger-riveted to the boiler shell. The old design, calling for waist bearer angle iron to be studded to the boiler in a continuous row, weakened the boiler shell, with resultant cracks developing.

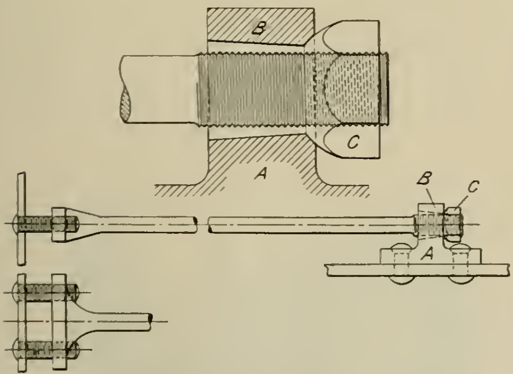
The pad is 5/16 in. thick and is riveted to the angle of the buckle plate with countersunk rivets and the whole accurately fitted and riveted to the boiler shell. The



Waist Bearer of Three-Cylinder Locomotive of the Southern Pacific

general form is shown by the accompanying illustration.

A form of flexible brace is used for the throat sheet, and is shown in detail herewith. A foot *A* is riveted to the shell. Its vertical lug *B* is bored on a taper with a spherical seat at one side to receive the nut *C* which is

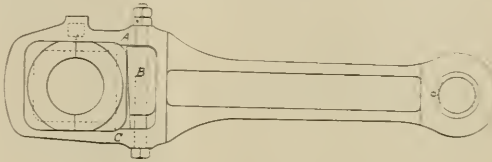


Throat Sheet Brace of Three-Cylinder Locomotive

screwed upon the end of the brace. At the other end the brace is widened to form a foot into which two stays are screwed. These stays are also screwed through the sheet and riveted over like an ordinary staybolt. With the stays at one end and the nut *C* at the other the brace is readily adjusted to the proper length. After the nut *C* has been adjusted the end of the brace is riveted over. With this arrangement of spherical seat and tapered hole the brace can adjust itself, without bending to any position that the throat sheet may assume relatively to the shell.

A description of the three-cylinder locomotive, built for the South Manchurian Ry., was published in RAILWAY AND LOCOMOTIVE ENGINEERING for November, 1924. That description was illustrated by line engravings of a number of details, some of which were identical in their general characteristics, if not in dimensions with the corresponding details of the engine under consideration, and may be referred to as descriptive of the same. Among these are the cylinder castings, the front driving axle and the inside connecting rod and the crossheads.

There is a slight variation in the design of the outside connecting rods. In the South Manchurian locomotive



Connecting Rod for Three-Cylinder Locomotive

the outside connecting rods had stub ends and were fitted with straps for carrying the brasses. In the Southern Pacific engines the brass at the wrist-pin end is made solid and keyed to the rod to prevent turning. It is bored to a neat working fit for the pin.

At the crank end the brasses are in halves and are bored 1/32 in. large, having a No. 22 (.028 in.) Birmingham wire gauge liner between them, which is removed when the rod is put upon the engine.

At the crank end the stub end is solid and is cut away at *A* so that the brasses may be put in and turned so as to slip into place. There is a wedge *B* and a key *C* for making the proper adjustments. The hole through the wedge is threaded and the bolt is screwed through it. Then, by turning the bolt the wedge may be moved up or down.

The specifications for the metal of these rods require that they should have the following chemical and physical properties:

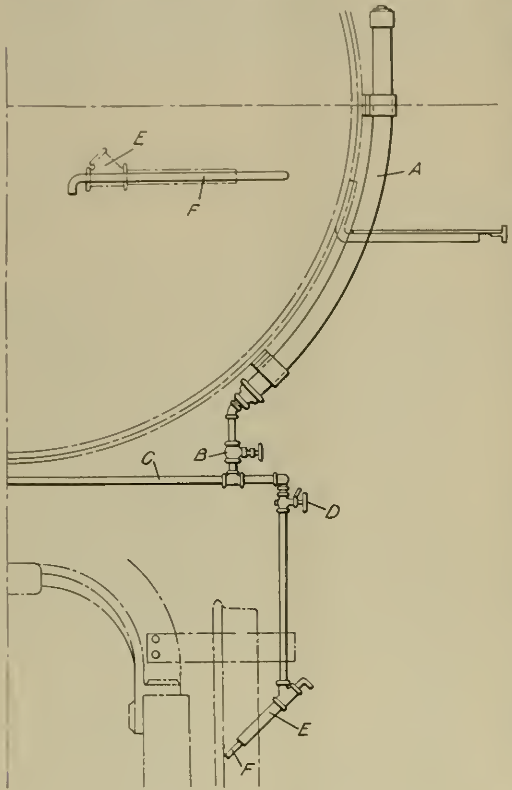
Carbon	.45 to .55 per cent.
Manganese	.70 to .90 per cent
Phosphorus	0.045 per cent maximum
Sulphur	.05 per cent
Minimum yield point.....	30,000 lbs. per sq. in.
Tensile strength........	80,000 lbs per sq. in.
Elongation in 2 in.......	22 per cent
Reduction of area........	32 per cent

The Flange Lubricator

The flange lubricator is formed of a simple combination of pipe fittings with a steel rod feeder bearing against the flange.

There is a piece of 2-in. pipe *A* bent to conform approximately to the curve of the boiler which is bolted to the left side only. The upper end is closed with a 2-in. plug through which a ¼-in. diameter hole is drilled for a ¼-in, by 2-in. reducer and a 45 degree elbow from which a ½-in. pipe is led. This 2-in. pipe serves as a reservoir for the lubricating oil. In the pipe leading down from the elbow there is a globe valve *B* and beneath it a tee with the pipe *C* leading from it to the right and left hand sides of the engine. At each end of this pipe another runs down to the flange to be lubricated. In each of these pipes there is a middle valve *D*, which is adjusted to permit a flow through it to give the desired feed. At the lower end of the vertical pipe there is a Y fitting having a piece of ½-in. pipe about 7 in. long screwed into the bottom end and extending in the direction of the flange. A piece of ½-in. diameter steel feed rod *F* 14 in. long and with a hook at one end to prevent it from falling out, is slipped into this piece of pipe and rests against the flange.

As it is loose in the pipe its weight holds it gently against the flange, where it moves up and down according to the variation in the relative movements of the boiler, to which the piping is attached, and the wheel. Thus the oil that



Flange Lubricator Used on the Three-Cylinder Locomotive of the Southern Pacific

passes through the needle valve trickles down through the vertical pipe to the feed rod and following it on down drips off against the flange that is to be lubricated.

Lateral Motion Adjuster for Driving Boxes

This arrangement, which was designed by Mr. Blunt, the mechanical engineer of the American Locomotive Co., is intended to automatically draw the driving boxes back to their central and normal position when they have been displaced for any reason, such as the side motion occasioned by the passage of curves.

The power required to force the box back to its normal position is obtained by a spring *B*. This spring is an American Railway Association standard G spring, and when placed in position is compressed to a length of 14⅛ in., at which length it is under a stress of 7,560 lbs., which becomes the minimum pressure available for moving the boxes.

The operating levers *A* are in the general form of an inverted *V* with the spring between the points thereof. The upper end of the levers are held by the spring. In the engraving of side elevation the lever at the left takes hold of the T head of the bolt *C*. This bolt passes through the center of the spring and has a bearing against the plate *E* by means of the nut. This plate *E* forms the right hand seat of the spring.

The lever at the right takes hold of the stirrup *D*, whose legs are on either side of the spring and whose crosspiece forms the left hand spring seat.

It is evident that if the upper end of either lever is moved outwardly, the upper end of the other being held stationary, the spring *B* will be compressed between the plate *E* and the stirrup *D*.

The arrangement is here shown as applied to the front pair of driving boxes, which have ⅞ in. of lateral motion between their outer flanges and the wedges. The inside flange is shown as tapered and nearly in contact with the wedge at 1.

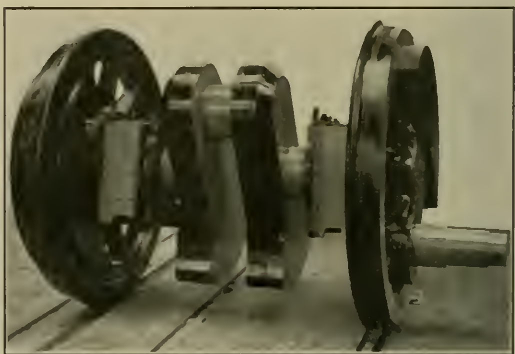
The lower ends of the levers *A* have two bearing points at each side of the boxes. At *2* there is a lug cast integrally with the lever which, under normal conditions, rests against the side of the pedestal outside the flanges of the box and the wedge. There is a lug of this kind on each leg of the lever. Then there are the rollers 3, of which there is one on each leg of the lever. These rollers are carefully adjusted so that when the lug is against the frame at 1, the roller will be just against the inside flange of the driving box. As the arrangement is stationary and fixed to the frames, the boxes are free to move up and down against the rollers.

The levers are pivoted on the shafts *F*, which are 2¼ in. in diameter and are held by brackets *G*, which pass over the top of the frame and are clamped to it by the bolts *H*. These bolts are cut with long threads and the attachment to the frame is effected by means of nuts.

Under ordinary conditions on a straight track, the arrangement occupies the position shown in the engraving, with all of the lugs against the pedestals and the four rollers against the inside flanges of the boxes.

If, on entering a curve, the driving box on the left is moved to the right, by the wheels, the journal of the axle slips through the box at the right, and there is no lateral movement of that box or of its lever, the lug at the right still rests against the pedestal at *2* and the roller 3 remains against the box, while the lever remains stationary with its upper end a fixed support for the stirrup *D*.

At the left, the wheel, by forcing the box to the right,

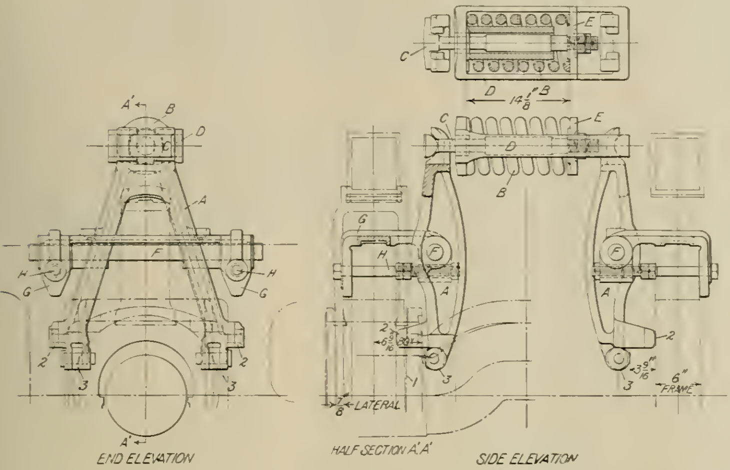


Crank-Axle of Three-Cylinder Locomotive

moves the lever and carries the lug away from the pedestal, leaving the rollers to transmit the thrust to the lever. As this lever is pivoted at *F*, its upper end moves outward, and the spring is still further compressed through the stress put upon it by the bolt *C*.

When the curve has been passed or the cause of the

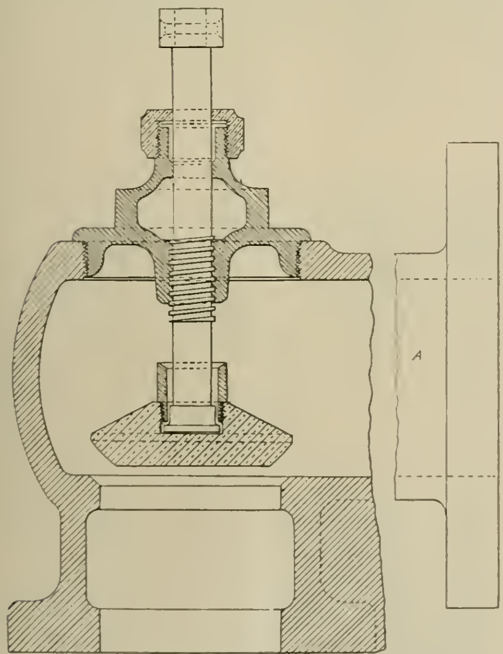
movement of the wheel removed, the spring draws the left hand lever back to its normal position again, and, in doing so forces the axle box and with it the wheels and axle back into their normal positions.



Driving Box Lateral Motion Arrangement Used on Three-Cylinder Locomotive of the Southern Pacific

Booster Cut-Out Valve

The booster cut-out valve is attached to the steam pipe on the left hand side. Ordinarily it is open at all times, the cutting out of the booster being accomplished automatically when the maximum speed for booster operation has been reached, unless done earlier by the engineer through other means.



Cut-Out Valve for Booster of the Three-Cylinder Southern Pacific Locomotive

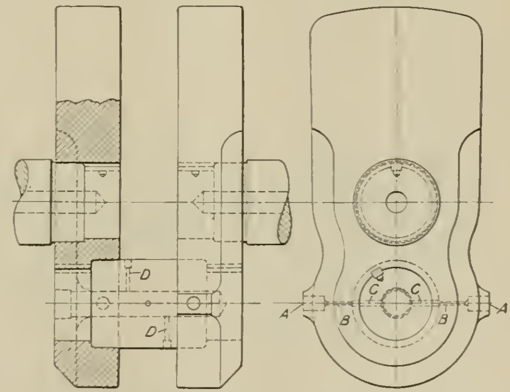
The valve is in the form of an ordinary globe valve, which is operated by a threaded stem. The casing of the valve *A*, has a flange for attaching, through a ground joint to the steam pipe.

The face of the valve is finished on a radius of 2$\frac{1}{2}$ in. while the seat is a straight cone of 45 degrees; a practice which is now the standard and is of great advantage in that the reaming of the valve seat and the maintenance of the reamers is greatly simplified.

No operating handle is put upon the stem, but instead the upper end is squared and a nut 1$\frac{1}{4}$ in. square is pinned thereon. This makes a firm hold for a wrench which must be used whenever the valve is to be opened or closed.

Lubrication of the Crank Axle Crank Pin

There is also a variation in the method of lubricating the center crank pin from that used on the South Manchurian machines. It will be remembered that, in those engines, the lubricant was carried through the center of the axle to the crank disc, and through it to the center of the pin to oil holes leading out to the surface. In the Southern Pacific locomotives, the crank axle is built up in the same way as before and is hollow; but the lubricant instead of being brought through it is carried in cups that are screwed into the crank discs at *A A*. They discharge into $\frac{3}{8}$-in. diameter holes *B* in the discs which open out to $\frac{1}{2}$ in. diameter at *C* in the pin leading to the center from which the lubricant flows out through the holes *D* to the bearing.



Crank Axle of Three-Cylinder Locomotive of the Southern Pacific Showing Method of Lubricating the Crank Pin

The Eccentric Crank

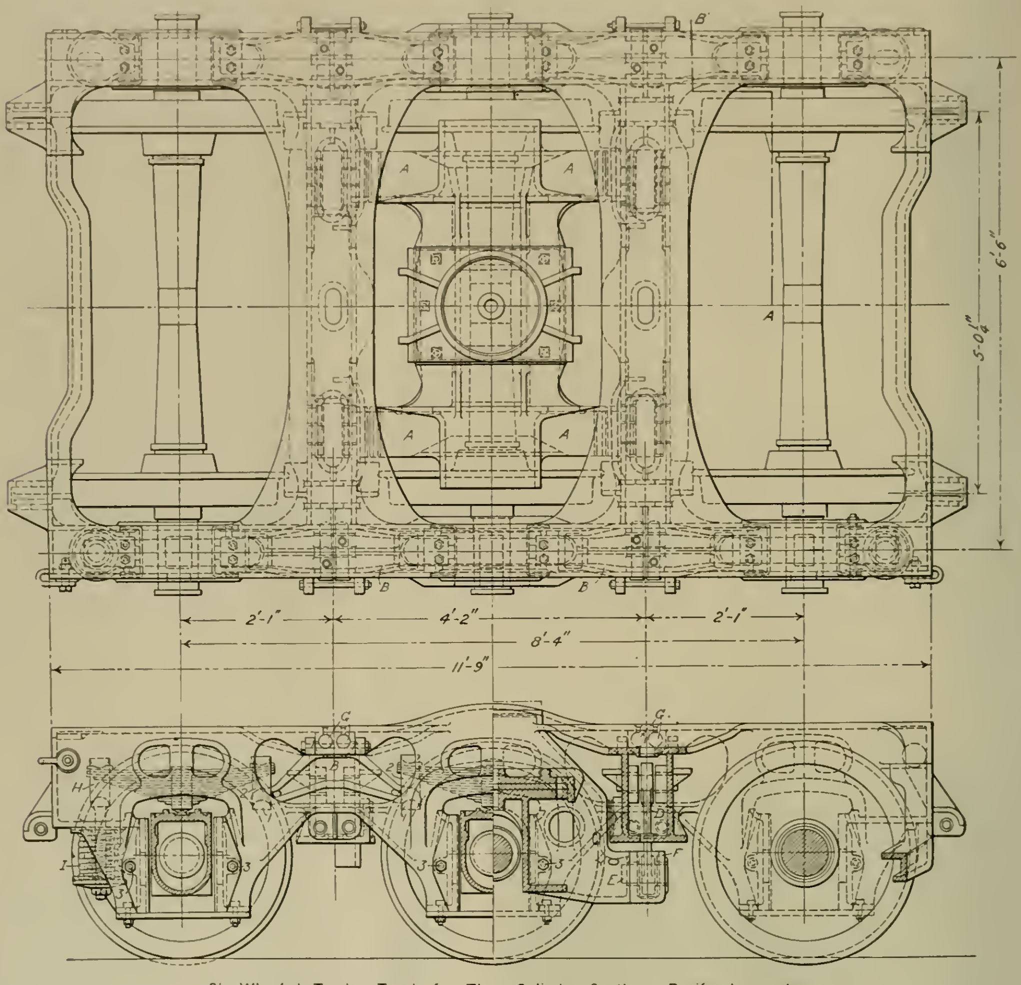
Another of the minor details worth noting is the eccentric crank which is of an improved design and which

had been previously developed and successfully tried on the Southern Pacific. The ordinary eccentric crank is provided with but one bolt for securing it to the crank pin, but as considerable trouble has been experienced by the crank working loose, the new design has been provided with two bolts for the purpose, as shown in the engraving. This double fastening has done away with the trouble referred to.

Six-Wheeled Tender Truck

One of the details that lends novelty to the general appearance of the locomotive is the six-wheeled truck that is used under the tender. The frame of this truck is of a single steel casting in which are included the wheel and end pieces and the two transoms. This casting is 11 ft. 9 in. long and 7 ft. 3 in. wide. The wheel pieces are of an inverted U section; the transoms are approximately of a box section while the end pieces are angles with a horizontal lug cast at the edge of the vertical leg. The thickness of the material is 1 in., with variations above and below that dimension in order to meet local requirements.

The bolster is also a steel casting the section of whose main body is that of an inverted U bestriding the center axle and stiffened by horizontal extensions at the top and bottom. It is provided with four arms *A* extending laterally and by which it is suspended from the transoms. Here, too, the general thickness is 1 in., except in the top plate, where it is 1½ in. The length of the bolster over the brackets for the side bearings is 4 ft. 10¼ in., and the overall lateral extension of the arms *A* is 4 ft. 7½ in.



Six-Wheeled Tender Truck for Three-Cylinder Southern Pacific Locomotive

The center plate is also a steel casting measuring 18½ in. by 26 in. It is a flat plate 1 in. thick with the ring and strengthening ribs on the upper surface.

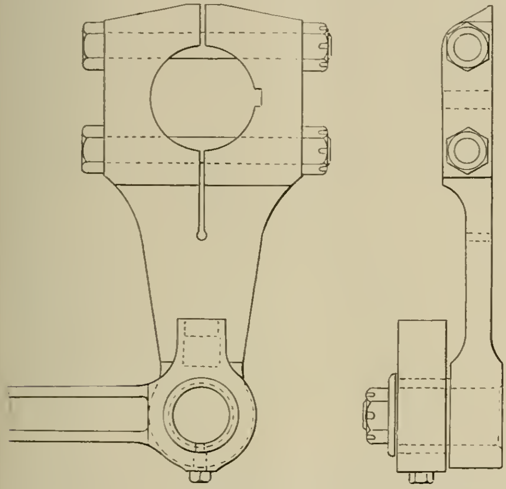
The fourth set of steel castings are the four equalizers *B* by which two-thirds of the weight of the truck is transferred to the springs.

Especial attention is directed to the bolster and frame, not only because of their size but for the complication of their shape and the difficulties that must have been en-

countered in casting them. They were cast by the Commonwealth Steel Co.

The bolster is suspended from the transoms by four hangers *D*. These hangers are attached, at their lower ends, to the bolster by the pins *E*, which are 3¼ in. in diameter, and pass through the two upwardly extending legs of the U Section, as shown at *F* of the arms *A*. This gives the pins a central bearing.

At their upper ends the hangers are carried by two 2½ in. diameter pins *C*. It will be noted that the outer one of these pins is located vertically over the center of the lower hanger pin, while the other stands in towards the truck center by a distance of 3 in. The result of this arrangement is that when the bolster swings in either



Eccentric Crank of the Three-Cylinder Locomotive of the Southern Pacific

direction, it turns about the inner pin on the side of the direction of motion and is raised accordingly; while on the other side, it swings about the outer pin, and, as this pin is directly above the lower one, the bolster on that side is raised only by the amount due to the arc of the circle through which it swings. The tendency of the suspension is, thus, to bring the bolster back to its central position.

The semi-elliptic journal box springs and the equalizers are placed between the vertical legs of the side frames. Two-thirds the weight of the truck is carried by rollers *G*, which are beneath the horizontal upper portion of the side frame and rest on a seat on the top of the equalizers. The ends of the equalizers are carried at 1 by the hangers 2, which, in turn, are supported by the ends of the semi-elliptic springs. The spring bands rest on the journal boxes, and the outer ends of the outer springs are held down by a hanger *H*, which passes down through the helical spring *I*, seated against the bottom of the frame.

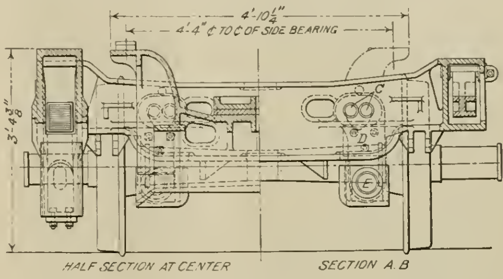
With the equalizers carrying a total of two-thirds the weight of one side frame, one-sixth of this load is transmitted to each end of the center spring, and to the inner end of the outer spring. The remaining third is carried by the helical springs *I*, each of which transmits one-sixth to the outer end of its end spring, thus giving to each semi-elliptic spring and to each journal box, one-third of the total load.

The pedestals are fitted with liners, clasping them and held in place by the bolts 3. These bolts are ⅞ in. in diameter and are applied with two lock washers, one under the bolt head and the other under the nut.

Brake shoes are applied to the end wheels only and are outside hung.

The wheels are 33 in. in diameter and the wheel base is 8 ft. 4 in.

The brackets for the side bearings are protected by a



Six-Wheeled Tender Truck for Three-Cylinder Southern Pacific Locomotive

filler block ⅛ in. thick and a wearing plate ½ in. thick, and the bearings are 4 ft. 4 in. from center to center.

The running gear is, therefore, quite flexible and, because of the equalization used, the load on each journal box is maintained nearly uniform.

A Ton of Coal Never Went So Far Before

Class 1 railroads in 1925 operated their freight trains with the greatest efficiency in the use of fuel on record, according to a tabulation of reports just filed by the carriers with the Interstate Commerce Commission and made public by the Bureau of Railway Economics. An average of 159 pounds of fuel was required in 1925 to haul one thousand tons of freight and equipment, excluding locomotive and tender, a distance of one mile. The average for 1925 was a decrease of 11 pounds under that for 1924 and was 24 pounds less than that for 1923.

The road locomotives of Class 1 railroads in 1925 consumed a total of 97,477,842 tons of coal, a decrease of 439,771 tons compared with the amount consumed in 1924 and a decrease of 11,997,000 tons under 1923. They also consumed 2,084,219,402 gallons of fuel oil, a decrease of 14,844,617 gallons compared with the preceding year but an increase of 104,351,402 gallons above 1923. This included fuel consumption in the freight and passenger service but did not include consumption in the yard service, shops or office buildings.

The factors contributing to this record were as follows:

1. Improved locomotives built with a view of increasing the tractive power while at the same time reducing the amount of fuel needed to operate them.
2. Increase in the length of "runs" of locomotives.
3. Educational programs carried on by the various roads to encourage fuel conservation and to instruct firemen as to the proper method of stoking locomotives.
4. Closer inspection of coal purchased by the carriers, for the purpose of obtaining a better grade of fuel than formerly.
5. Greater expedition in the handling of trains through terminals and also along the lines, due to improved methods of classifying freight so as to reduce delay in transit and also to the more intensive use of signal devices which expedites the movement of trains without necessarily increasing the actual speed of trains.

Railroad Electrification Developments in 1925

Virginian Railway Project Largest in Electric Field

Unquestionably the outstanding as well as the most spectacular activity in railroad electrification during 1925 was the inauguration of electric service on the Virginian Railway. This incident was doubly significant in that it introduced to railroading the world's largest and most powerful motive power and with it the movement of the heaviest tonnage in history. Trial runs were made on the 14 mile grade between Elmore and Clark's Gap where the ruling grade is about 2 per cent and the maximum grade 2.11 per cent. Trains of approximately 8,000 tons were hauled up the grade at 14 mph. or twice the speed of a similar train hauled by three Mallet type steam engines.

More than half of the 36 motive power units ordered by the Virginian Railway have been delivered by the Westinghouse Company and are being used in triple-unit locomotives in regular service, hauling trains of exceptional tonnage.

The only new steam railroad electrification project announced during the year was that of the Great Northern Railway for the extension of its existing electrified section, at the same time changing from the present 6,600-volt three-phase system to an 11,500-volt single-phase system. Four new locomotives included in the contract for electrical equipment to be built by the Westinghouse Electric & Manufacturing Company, will be of the motor generator type. Phase converters will be installed on the 6,600-volt electric locomotives now in service to make them serviceable on the revised system. Secondary locomotives whose power will be drawn from the main locotives will assist in moving heavy freight trains over the steep grades in the Cascades.

In keeping with the legislation requiring the abandonment of all steam locomotives within the city limits of New York, the Staten Island Rapid Transit Company, a subsidiary of the Baltimore & Ohio Railroad, also officially inaugurated electric service on the East Shore and Perth Amboy Divisions last July. Multiple-unit trains operate from a 600-volt d-c. over-running third rail. Power is supplied from five substations whose aggregate capacity is 10,000 kw. and all except one of which is equipped for complete automatic control from a centralized supervisory system in the traffic operator's headquarters. Primary power is furnished at 33,000 volts, 3 phase, 60 cycles from the reconditioned Livingston power plant of the Staten Island Edison Corporation.

It is of more than passing interest to know that this is the first instance where remotely controlled automatic substations have been used in steam railroad service.

Conceded as the most unique development in electric motive power during the year was the motor generator type electric locomotive completed at the Ford Motor Company for use on the electrified section of the Detroit, Toledo & Ironton Railroad. Mechanical parts were built by the Ford Motor Company and electrical equipment by the Westinghouse Company according to Ford specifications which incorporated the unique feature of drawing power from a high potential single-phase trolley and utilizing the inherent characteristics of low-voltage direct current motors.

This development might be considered as a step forward in the embodiment of the salient points of both a-c. and d-c. systems in one locomotive.

The Long Island Railroad started electric service on the 28-mile double-track section between Jamaica and Babylon in order to effect a more economical handling of the rapidly growing commuter traffic on its system. This extension has increased the capacity of the entire system. The terrible congestion which previously existed at Jamaica has been eliminated as it is no longer necessary to transfer from electric to steam trains for the remainder of the outbound trip from the city, and vice versa. Delays have been reduced by the decreased number of stops necessary for steam trains.

The Jamaica-Babylon extension required six new substations, two transformer stations for increasing the transmission line voltage, a new transmission line from Lynbrook to Babylon and the reconstruction of several other transmission lines. All electrical equipment was supplied by the Westinghouse Electric & Manufacturing Company.

The service on the Long Island is featured by the remarkable growth of the commuter traffic during the twenty years of operation. The increase at various points ranges from a minimum of 500 per cent to the astounding figure of more than 20,000 per cent.

Shortly after announcement was made that the Insull interests of Chicago had obtained control of the Chicago, South Shore & South Bend Railway, formerly known as the Chicago, Lake Shore & South Bend System, it was made known that the entire system would be rehabilitated. The present 6,600-volt a-c. system which has been used for 18 years will be changed to 1500-volts d-c. to provide a direct connection with Illinois Central for entrance into Chicago.

The contract for electrical equipment awarded the Westinghouse Electric & Manufacturing Company includes four 80-ton electric locomotives and equipments for 30 motor-cars and 28 trail cars. Half of the new substations will be of the mercury rectifier type.

This stupendous undertaking is a gallant project in view of the fact that the South Shore lines are paralleled by first class hard-surface roads on which independent motor bus companies are now operating and is also in competition with excellent steam line service. However, the Insull interests believe that good service via electric cars begets business and have, therefore, launched a program which emphasizes the two important factors of passenger comfort and increased speed in operation.

The New York, New Haven & Hartford Railroad, already conceded to be the most comprehensive electrification in the world, extended its electric service to include the Danbury Branch. This extension eliminates the necessity for changing engines at South Norwalk and also affords patrons in that vicinity of the state the same service now enjoyed on the main line. Substantial economies through the more efficient utilization of electric locomotives and release of steam locomotives for other duties are the aims in this extension.

New motive power equipment ordered by the New Haven during the past year included three switching locomotives similar to the 16 which have been making such enviable records for several years, 13 multiple-unit cars and 21 trail cars. Several 250 hp. gasoline-electric rail cars were also ordered by the New Haven for branch line service.

The Illinois Central Railroad 1,500-volt d-c. suburban electrification at Chicago continues to progress. During the past year contracts were awarded for 130 motor cars, 85 trailers and for the reconditioning of 45 trailers now

in steam service, for electric operation. A motor-car and trailer will be semi-permanently coupled together to form a unit, five of which will constitute each of the multiple-unit trains in service.

The Pennsylvania Railroad has already started preliminary work on the proposed electrification of its line from Philadelphia to Wilmington, Del.

This road also placed orders with the Westinghouse Company for electrical equipment for some switching locomotives which the railroad company is building in its shops, and 11,000-volt a-c., 600-volt d-c. trail-car equipments for multiple-unit service.

Activity Abroad

Abroad, electrification plans are active principally where electric service is already in existence. Some other countries, however, are studying its possibilities.

The State Railways of Czecho-Slovakia are now electrifying 73 miles of main line between Prague and Pilsen, using the 1,500-volt d-c. system. Four electric freight locomotives and one electric passenger locomotive are being built by Kolben & Company in that country in accordance with specifications furnished by the Westinghouse Electric & Manufacturing Company.

Early in 1925 the Paulista Railways of Brazil ordered a new 140-ton 3,000-volt d-c. Baldwin-Westinghouse electric passenger locomotive to be practically a duplicate of those previously supplied. Late in the fall, another contract was let for four 118-ton Baldwin-Westinghouse electric freight locomotives also to be duplicates of the two supplied on the original contract several years ago. This additional motive power is necessitated by a recent extension of the electrified zone.

In Japan, the Government Railways are steadily progressing with the electrification of several of its lines. The Chuo or Central Line, and the Tokaido Line from Tokio to Kobu are now involved. Eight more electric passenger locomotives, two of which are for local service and the rest for high speed operations, are nearing completion at the Westinghouse works at East Pittsburgh, Pa.

The Netherland State Railways established rapid transit electric service by multiple-unit equipment during the year.

In the Dutch East Indies, the main lines on the island of Java have been electrified within the past year to enable them to meet the requirements of the rapidly growing industrial development on that flourishing island.

In addition to these developments abroad, Mexico, Chile, Spain, France, Russia, Germany, Austria and Italy and some other countries have made definite plans for or are seriously considering electrification as a modern improvement to expedite traffic and conserve fuel.

An analysis of the locomotives completed, building or ordered in 1925 shows that not quite one-third of the total number are for direct-current systems with voltages of 600, 1,500 and 3,000. The a-c. locomotives are all for 11,000 or 22,000-volt systems. Some of the units are designed to operate d-c. motors from a-c. overhead similar to the idea used in the Ford locomotive.

Weights ranged from 75 tons to 642.5 tons, total, in working order.

Just one locomotive was specified for passenger service exclusively. Four were combination freight and passenger, but by far the greater number were for either road freight or switching service.

Passenger equipment consisted principally of more than a hundred multiple-unit motor and trail car equipments, of which some 40 were for a-c. operation. The great amount of d-c. equipment is a result of the South Shore electrification at Chicago.

European Motive Power Trends*

By W. H. Finley, Consulting Engineer

There is great activity in Europe and America is developing a more economical form of motive power than that now furnished by the steam locomotive. Technical papers and trade papers, even newspapers, contain, from time to time, articles describing new types of motive power and predicting a revolution in railroad transportation, but I feel that there will be no sudden revolution in railroad transportation. It will, I think, fortunately follow the careful step by step progress that has taken place in the past.

With the view of determining the state of the art in Europe, I visited, in October and November of last year, France, England, Switzerland, Germany and Sweden, calling upon the various railroads and prominent manufacturers. I found that they were in as much doubt in Europe as to the type of major motive power that would be developed as we are in the United States.

The opinion seems to be divided between the turbo-locomotive and the Diesel locomotive. With all the publicity that has been given these two types, yet I did not find one turbo-locomotive in commercial use in Europe and but one Diesel locomotive and that one in operation in Soviet Russia. This locomotive was built in Germany and has been in operation in Russia for some time. Its performance and record is being watched carefully by railroad men and manufacturers.

I was surprised to find that the consensus of opinion was against the practicability of the Diesel locomotive electrically driven. As to the steam turbine development, under the system Zoelly and system Ljungstrom, outside of one or two experimental locomotives, the only one in actual use was the steam turbine locomotive in Sweden under the Ljungstrom patents. This locomotive is held at Stockholm on the Swedish State Railways for experimental and demonstration purposes, although it is occasionally used by the Swedish Railways for special runs when they are short of other power. Ljungstrom company has had built and delivered to the Argentine, a steam turbine locomotive which was received in the latter country in November and was expected to be in active service by this time. This locomotive, as would be expected, shows some improvements over their first experimental effort.

The Beyer Peacock & Co., Ltd., of Manchester, England, is building a turbo-locomotive under the Ljungstrom patents and expected to have it completed by this date. I understand it will be given its initial test on the London Scottish & Midland Ry. on the run from London to Glasgow. I was advised by an officer of this company that they had under consideration the development of a Diesel locomotive and would be prepared to furnish either type.

At the plant of the Swiss Locomotive & Machine Works at Winterthur, I saw a demonstration of a 100 horsepower,

*Excerpts from a paper presented at the Western Railway Club, Chicago, Ill., February 15th, 1926.

4-cycle. Diesel locomotive which they used for switching around their yards. The engine operated at 550 revolutions and weighed 40 lbs. to the horsepower. The transmission was an oil operating clutch gear and the control was perfect—the locomotive being reversed from five miles an hour ahead to equal speed in reverse without stopping the locomotive.

At the works of Henschel & Sohn, Cassel, Germany, I saw the testing around their yards, of a 400 horsepower Diesel locomotive using solid injection. This locomotive was equipped with a Lentz gear transmission. While admitting that the present type of design is limited to slow speed of both driving and driven shaft and a limited range of speed of the driven shaft as well, belief was expressed that it could be so modified as to admit both high speeds and a wider range. Mechanical efficiency was given as 80 per cent. If this 400 horsepower Diesel locomotive with the Lentz transmission works out satisfactorily, Henschel & Sohn expect to build a 1,000 horsepower of the same type. Final decision will depend on the further reports of the operation of the Russian 1,000 horsepower Diesel electric locomotive. Electric transmission was not regarded favorably by this company—they claiming that it was too expensive (first and last), heavy, bulky, and too complicated. Their opinion is that the Diesel locomotive (provided that the transmission can be solved) will be in limited demand for:

(a) Intermittent yard switching and where there is a penalty against smoke and dirt.

(b) On branch and main line work of railroads in localities where water is scarce—where cheap oil fuel is available and coal prices are high.

Henschel & Sohn are now developing and building a turbo-condensing locomotive tender for coupling to a 1,200 horsepower piston locomotive. The tender will contain a low pressure turbine with drive and condenser, thereby adding approximately 600 horsepower to the draw bar pull of the locomotive without the expenditure of additional fuel. The oil in the exhaust steam from the reciprocating engine will be extracted to the extent of about 95 per cent. A favorable result is anticipated as a water cooled surface condenser is less affected by oil than an air cooled type. This company has also completed plans for a 2,000 horsepower Zoelly type turbo-locomotive, featuring boiler, turbine with drive, and condenser on one frame. If this turbo-condensing tender proves successful they will proceed with a 2,000 horsepower rigid wheel base locomotive and low pressure tender.

At the Krupp plant at Essen, Germany, I looked over the Krupp-Zoelly turbine locomotive that had been completed and made some test runs on the German State Railways. This locomotive, I think, is a decided improvement over the experimental Zoelly turbine locomotive that I saw at the plant of Escher Wyss & Co., of Zurich, Switzerland. It must be remembered, however, that the experimental locomotive at the Escher plant was a converted steam locomotive and in building the Krupp-Zoelly machine they got a better arrangement and a more symmetrical unit. They are giving special attention to the development of a Diesel locomotive and are building a 1,000 horsepower locomotive type, featuring a gear drive and a magnetic clutch. This is their attempt to develop something to take the place of the electric transmission. They also have plans under way for a 2,000 horsepower Diesel locomotive but are not pushing it, claiming that they are waiting for more information as to the performance of the 1,000 horsepower Diesel locomotive in operation in Russia.

Mr. Hagenbucher, the chief engineer, seemed a strong believer in the turbo-condensing locomotive. He did not think there was any revolutionary change pending but rather, with the increasing demand for more efficient motive power, there would come a gradual introduction of the turbo-condensing type. He thought there would be considerable development of Diesel locomotives for special purposes or places, such as where water is scarce and coal is expensive but oil cheap and available. It is considered to have a field also in industrial switching and short haul work where special conditions are in its favor.

In all the places visited, I found a decided doubt in the minds of many as to the commercial success of the Diesel-electric engine now in use in Russia. Some were very emphatic in their opinion that it was not a success, claiming that troubles had developed and the electric transmission was one of the items causing the most concern.

There is no doubt that the introduction of a low compression, solid injection engine has given the semi-Diesel quite a boost and as a result the steam advocates have awakened and are making great developments in the prime mover using steam. At the works of Henschel & Sohn, Cassel, previously referred to, I saw a converted steam locomotive from the German State Railways, that generated steam at 90 atmosphere and used a working pressure of 60 atmospheres, or 900 lb. When I saw this locomotive it had just come in from a run on the German State Railways.

The demand for a small self-propelled car is just as insistent in England and on the Continent as in America. In conversation with the chairman of the board of Beyer, Peacock & Company, Ltd., he stated that what England needed was some form of small efficient self-propelled railroad car to enable the railroads to compete with the steam and petrol buses and lorries used on the highways. In Germany I found the same condition, and the railroads are developing both Diesel and steam power for motor car work. Cars of both types in actual use are about equally divided, with the Diesels averaging slightly higher in power. Larger power units of both types of cars are contemplated. The steam cars are coal fired and are reported as having the advantage over the Diesels in both first cost and operating cost. Some plans of these cars suggest the revival of the Ganz idea. I also understand that plans are being developed for a small (500-hp.) automatically coal fired locomotive which will be operated by one man.

The Swedish State Railways are going in rapidly for electrification and this fact is engaging the attention of their organization to the exclusion of many other things. The State Railways own and operate no internal combustion motor cars. At one time they had a 100-hp. Diesel car, but it was too small for their purposes and therefore was disposed of. There are, however, some fifty Diesel electric cars owned and operated by small, private roads in Sweden which are reported as giving good service. The State Railways are now trying out a 300-hp. Diesel electric locomotive, reported as performing satisfactorily. The inspection of this car showed that it is about 40 ft. in length and aside from an 8-ft. baggage space is all power plant. The engine was being overhauled at the time of inspection.

The history of self-propelled cars is rather a long one. The earliest steam powered railroad motor car on record was built in England in 1847. There was apparently little activity in this line until 1897. From that time until 1910 several hundred steam powered railroad motor cars were built in this country and abroad. The early steam self-propelled cars were mostly of low pressure ranging from 160 lb. working pressure to 200 lb.—the boiler generally of the vertical fire tube type.

In 1903 Ganz & Company, Budapest, Austria, built a car with a vertical water tube boiler carrying 250 lb. pressure. In 1907 this company built a car for the Florida East Coast and this was the first Ganz type of

car used in the United States. This company met with considerable success and about 200 cars have been put out.

In recent years there has been increased activity in the production of self-propelled cars and they seem to be confirmed now to gasoline directly connected, and gasoline electrically driven. Some of the latter are reported as giving excellent service. There has also in latter years been a decided tendency to increase the capacity of these self-propelled cars so that they can haul a trailer or two. Some are now built of about 300 to 400-hp. capacity. I think increasing difficulty will be found with the internal combustion type in the larger units unless a satisfactory transmission is developed.

I feel that what the railroads need is a secondary power, something between their small standard locomotives and the light weight self-propelled cars. Whether such a car will take the form of the internal combustion engine or steam is still a matter to be determined. I feel that in cars of 500 hp. It will be possible to develop a steam car that will compare favorably in efficiency with the internal combustion type and would not require the building up of a special personnel for their maintenance. Steam has proved a very reliable source of power for railroad transportation owing to its flexibility.

Since Watt, over 100 years ago, called R. A. Trevithick a potential murderer for proposing to operate boilers at the dangerous pressure of 60 lb. per sq. in., every subsequent increase in steam pressure was opposed by the conservative majority, and it was not until our electrical friends demanded something more efficient in the way of high speed for their purposes than the existing steam engine as a prime mover, that the steam turbine was developed to meet this demand. The steam engineer, owing to established precedents, opposed higher speeds and high pressures. Electrical engineers, on the other hand, not being tied up to so long a line of precedents were more progressive and the steam people were forced to meet their demands. I think I still notice in this country among steam users, objection to high rotative speeds in turbines. European engineers seem to have pushed ahead of us in this respect.

The same feeling existed as far as the boiler was concerned and high pressures were looked at with alarm, but the increase in boiler pressure has gone on until now 500 lb. and more is accepted. We have now reached the point of giving serious consideration to the Benson superpressure boiler. In this boiler it is proposed to generate steam at a pressure of 3,200 lb. at a temperature of 706 deg. F. An experimental plant has been constructed at Rugby, England, which it is expected will be in operation about the first of the year. A 50 per cent interest in the boiler has been disposed of to the firm of Siemans & Schuckert, Germany, and the latter company has erected a 2,000-kw. plant at Berlin for experimental purposes.

To give you an idea of the difference in opinions of steam advocates and Diesel motor advocates, I will quote from a paper of J. S. Haldane, M. D., F. R. S., "The Maximum Efficiency of Heat Engines, and the Future of Coal and Steam as Motive Agents," read before the Institution of Mining Engineers on June 16, 1925. Mr. Haldane says:

"At the present time steam engines and oil engines are running a neck to neck race as regards many employments, while elsewhere the oil engine is being applied increasingly to quite new purposes, where no heat engines had previously been applied. In the opinion of many persons the steam engine is bound to be displaced more and more by the internal combustion engine. This opinion is largely based on the current academic doctrine that the efficiency of a heat engine depends on the absolute temperature reached in the engine. In this paper I have taken my courage in my hands and thrown to the winds the academic teaching, backed though it be by the names of men to whom the whole would has had good reason to be grateful. But I wish now to go a step farther. I think that the development of the steam engine has been very greatly hindered by the fallacious teaching associated with Carnot's cycle. Engineers have been prevented from seeing clearly what the maximum efficiency is being needlessly lost, and how the steam engine can be modified to suit varying circumstances without loss, or with minimum loss, in efficiency. . . . As regards modifications of the steam engine to suit varying circumstances, it seems to me that small engines, working at very high pressures, and with correspondingly small tubular boilers, will come more and more into use. From a quite recent paper by Professors Mellanby and Kerr I gather that we may expect steel under heavy pressure to stand temperatures up to about 900 deg. F. or 480 deg. C. But even at the lower temperature of 710 deg. F. or 374 deg. C. we have reached the critical temperature of water and a pressure of 210 atmospheres, or over 3,000 lb. per sq. in. At present I can see no fundamental objections to using steam up to or above these pressures; but in any case a steam pressure of 100 atmospheres, with a corresponding temperature of 600 deg. F. seems well within reach. The steam engine in the future will, I think, nearly always be a condensing engine, even if the steam is condensed at or above boiling point. The familiar puff of locomotive and other steam engines will then no longer be heard; and where weight of and space occupied by the engines are of great importance, multiple-expansion engines and low pressure turbines will also disappear. With all due respect to well known persons who have recently been writing on the subject of Diesel engines in *The Times*, I do not think that the Diesel engine will have even a dog's chance against the future steam engine for ship propulsion."

This is the opinion of apparently an extreme steam advocate. In the discussion of this paper, Professor Henry Louis of Newcastle-on-Tyne, expressed himself as follows:

"I admit that I am a believer in the internal combustion engine rather than the steam engine, but my opinion is not based as Dr. Haldane suggests, 'on current academic doctrine'; it is based on hard facts. I find in Kempe's Engineers' Year Book extracts from the Electricity Commissioners' Reports for 1924 which give the lowest coal consumption for a steam engine as 1.81 lb. per kw., as against the lowest oil consumption of 0.64 lb. One such facts speaks more than pages of Carnotcycle theories."

Regardless of whether the prime mover is a gasoline engine Diesel motor, or steam turbine, it is very important that the transmission between the prime mover and the secondary shaft be of such flexible character that it will not transmit shocks and jars from the track to the prime mover. This is so thoroughly recognized by railroad men and builders of locomotives and motor cars that probably more attention is being given it today than the type of prime mover. I found that they are not only building various kinds but any number of projects are in the air. Unfortunately so many of them fail to get down to earth.

We have been told, from time to time, that the steam locomotive would be scrapped in favor of some new form of power, but it is still doing good and reliable work for the railroads, and will continue to do so for many years to come.

I believe, however, that there are improvements that can and will be made that will greatly increase the value of the steam locomotive for transportation purposes. I believe that some of the power on the railroads could be improved greatly by the addition of a low pressure

steam turbine tender, adding greatly to the tractive force without any additional fuel consumption, thereby making unnecessary the purchase of heavier power.

I believe the next improvement will be in the use of higher pressure steam and with a tender carrying a low pressure turbine, or possibly the combination in one unit of a high pressure piston locomotive and steam turbine. I believe these improvements will come in the immediate future.

Assuming that the Benson super pressure boiler becomes a commercial success, I can vision the operation of railroad terminals, and even suburban trains by steam, without any smoke, dirt, or noise. This will save railroads the large expense that electrification would entail.

What Locomotive Builders Are Doing Here

Discussion on Recent Locomotive Developments in the United States

By James Partington, American Locomotive Company

Mr. Finley with his background of long railroad experience was certainly well qualified to make a tour of Europe and review the different products that they have in the air and some of them being worked out. He has given us a very careful synopsis of what he has seen.

I am not telling anything you do not already know, but I think it might be well to point out that what is being done along engineering lines in the United States is to some extent at least a counterpart of what is being done abroad.

The main line operation of the roads in the United States calls for the handling of much greater traffic and, therefore, much heavier and larger units are required than are handled abroad, so that in thinking about the new types of locomotives that have been mentioned here tonight we must think of them in larger units that will be comparable with the largest and most efficient steam locomotives in use on our railroads.

The steam turbine locomotive, which is being developed abroad, shows great fuel economy, but it also entails a much greater first cost and in our service probably much higher maintenance charges would be involved. If built in units of comparable size for our service, say 2,500 or 3,000 hp., the condenser necessary would be of formidable proportions.

The provision of forced draft would also be a large question to solve. We heard the statement made by one of the English engineers that the puff would be subtracted from the locomotive, but if the puff is subtracted from the locomotive some other means of forced draft must be provided. That would have to be probably a turbine of some description and to provide the necessary draft for a large locomotive that turbine blower would have to be of large proportions.

On our railroads these large motive power units are more desirable than the smaller units. In Europe the cost of fuel is relatively much greater than it is in this country and the cost of labor is relatively much less and it is also easier to obtain the efficient labor to maintain and operate these more highly developed units.

The turbo-locomotive as a design of locomotive has not been considered very seriously in this country by any of the railroads. I think it has been reviewed by the principal locomotive builders, but thus far I think I am safe in saying that there has been no pronounced demand of any sort for even a trial of the turbo-locomotive, because of the problems that are presented in attempting to construct and operate a turbo-locomotive of large size.

The application of the Diesel oil engine to locomotives is making progress on our railroads and many executives are watching its developments closely. Oil electric locomotives are now in use in the switching yards of the Central R. R. of New Jersey, the Lehigh Valley and the Baltimore & Ohio in New York City, and in switching and transfer service on the Long Island R. R.

These locomotives are equipped with the Price & Rathburn type of oil engine and are of 300 and 600 hp. The New York Central will soon place in service a 750 hp. Ingersoll Rand oil electric locomotive in freight service and an 800 horsepower in passenger service on its division.

Orders have also been placed by the Chicago & North Western, the D. L. & W., the Reading and the Erie for Ingersoll Rand oil electric locomotives.

The construction of locomotives of this type of greater horsepower no doubt will be an accomplished fact in the near future.

The advantages of this type of locomotive have been pointed out by Mr. Finley and those now in service have been installed because principally they meet the smoke ordinance restrictions in districts where they have been put in service. Future developments and possibly the perfection of the mechanical transmission may greatly extend the use of this type of power.

In designing a turbo-electric, turbo-locomotive, oil electric locomotive, or any type of straight electric locomotive or any Diesel locomotive with mechanical transmissions, we must keep within the load limits as designed for steam locomotives. This will make necessary often a large number of units arranged to operate by multiple control as one. The oil electric and straight electric locomotives are readily adaptable to such control and in that respect are more readily available than the other types if the service to be performed will bear the burden of the higher initial cost involved. This is probably a partial explanation of why we have the electro locomotive installation and why we are getting the Diesel oil engine locomotive installation in this country, because they give promise of being developed so that they can be operated in as large units as our steam locomotives.

The electrification of a number of our railroads has progressed largely because of necessity and some of the developments which have been made, notably one recently on the Virginian Railway where a section of the track has been electrified to increase the tonnage output of that section of the track, are good illustrations of what can be accomplished by straight electric locomotives.

The adaptation of the Diesel oil engines to locomotives will have that same valuable feature that as the oil electric or the straight electric or the Diesel are developed for larger horsepower they can be arranged for the multiple operation.

In considering the future of the locomotive, Mr. Finley has given us a very conservative statement that there will be no revolutionary changes. I think this is entirely true.

The different types of locomotives will have to prove and establish themselves. The steam locomotive is still being improved. We know that nearly every year of steam locomotive construction in this country there have been major or minor changes from the locomotives previously built indicating that the engineers of the builders and the engineers of the railroads still have in mind better improvements and further increases in the efficiency of the steam locomotive.

In the last five years there have been numbers of changes which have increased the efficiency of steam locomotives.

To enumerate a few of them we might mention greater allowable weight of drivers, greater factors of steam efficiency, higher superheat, higher working practice, the condition of steam by aqueous formation, steam generation, economy of heat units, the closer study of road operation and more careful study of motive power to meet special conditions and the use of higher pressure steam. This is gradually coming on a number of our railroads. We have one locomotive in operation in this country with 350 lb. pressure and a large number of locomotives with 250 and a few at slightly higher pressures than that. The builders and the railroads must each feel their way in adopting higher pressures.

I feel that all of these types of locomotives will have a place and that there will be continued development along the lines that are being gradually established in all such types.

The Ultra-High-Pressure Locomotive

An Ultra-High-Pressure Compound Three-Cylinder 4-6-0 Superheated Steam Express Engine for the German State Railways

Rumors of the construction in Germany of a locomotive having a boiler that carries an exceedingly high pressure have been in circulation for some time. The engine and boiler which is here illustrated was developed by the Schmidt Superheated Steam Company of Cassel Wilhelmshohe and the final design worked out by Henschel and Son of Cassel.

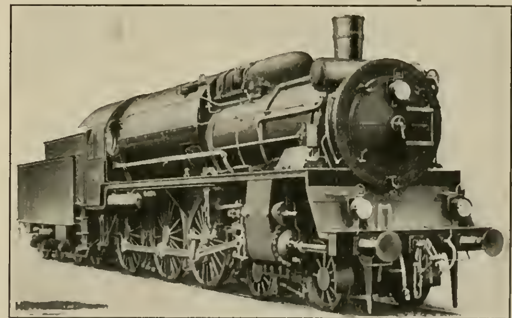
Nobody had hitherto tackled the construction of a real ultra high-pressure locomotive. The requirement of absolute safety in locomotive boilers which are restricted to a minimum weight and yet have to stand the roughest strains, implied particular difficulties, which have, however, been overcome in a most satisfactory manner.

In order to avoid the difficulties inherent to the design of a downright "ultra-high-pressure" boiler, the latter was built for two working pressures, 853 lbs. p. sq in. working pressure being carried in the back end, or ultra-high boiler, as it may properly be termed, and 199 lbs. p. sq. in. in the boiler barrel.

The inner firebox is formed by water-tubes the bottom ends of which reach into the water chambers of a hollow foundation ring, whilst their upper ends discharge into steam collectors. The system is filled with chemically pure water up to the tube ends in the steam collectors. From the latter, steam rises through vertical tubes to heating coils mounted in the ultra-high-pressure boiler above the firebox. The heat from the coils is absorbed by the water in the ultra-high-pressure boiler, and the condensate falls back to the foundation ring chambers through another set of tubes and thence begins the circulation anew. Heating the ultra-high-pressure boiler is thus operated indirectly, and the use of the chemically pure water implies the advantage of avoiding the detrimental formation of scale in the firebox water tubes. The working pressure in the firebox and the heating coils is 1,100-1,300 lbs. sq. in. in the ultra-high-pressure boiler it amounts to 853 lbs. p. sq. in.

The boiler barrel working at 199 lbs. p. sq. in. is of the standard pattern and heated by a tube system. In order to keep the formation of scale at its lowest, there is, besides the customary steam dome, a special feed dome with an angular grid over which the feed water is sprinkled in a thin spray. For the same reason the feed water for the ultra-high-pressure boiler is pumped across from the barrel, so that deposits of tartarous matter in the ultra-high-pressure boiler are restricted to a minimum.

The 850 lbs. p. sq. in. steam generated in the ultra-high-pressure boiler is led to an ultra-high-pressure regulator and after having undergone the superheating process in a small tube superheater arranged in the lower portion of the flue-tubes, it enters the steam chest of the ultra-high-pressure cylinder located between the frames. The steam produced in the boiler barrel flows through the dome regulator and thence through another small tube superheater provided in the upper flue-tubes. On its way from the superheater collector to the two normal pressure cylinders outside the frames, the highly superheated normal pressure steam mixes at 575 degrees Fahr. with the exhaust steam from the ultra-high-pressure cylinder showing but a small remainder of superheating, and after having performed work in the normal pressure cylinders, it is emitted through the blast pipe and the smoke stack.



Ultra-High-Pressure Steam Locomotive of the German State Railways

For the trial execution the German State Railways have set apart a 4-6-0 three-cylinder superheated steam express locomotive, class S 10^2, which is particularly suitable for alteration inasmuch as the chief work to be done consists of replacing the boiler and the inside cylinder. The outside cylinders with their respective value motion, the high pressure piston valve working levers, and

the whole driving gears of the engine remain unaltered. The locomotive was shown at the German Traffic Exhibition at Munich, it will now perform the trial runs and pass the steam consumption tests, the results of which will be made known. It is expected to save about 25 per cent on fuel, or, on the basis of equal fuel consumption, realize an increase of output from 35 to 40 per cent.

The principal dimensions of the locomotive are hereafter given:

Diameter of ultra-high-pressure cylinder	11 7/16 in.
Diameter of normal pressure cylinders (2)	19 11/16 in.
Piston stroke	24 13/16 in.
Diameter of driving wheels	6 ft. 6 in.
Diameter of truck wheels	3 ft. 3⅜ in.
Wheel base, rigid	15 ft. 5 in.
Wheel base, total	30 ft. in.
Working pressure	850 and 199 lbs. p. sq. in.
Grate area	28 sq. ft.
Heating surface in firebox (internal)	211 sq. ft
Heating surface of boiler	1,525 sq. ft.
Heating surface in tubes, internal	1,313 sq. ft.
Heating surface of superheater	974.3 sq. ft.
Weight empty	about 185,000 lbs.
Weight in working order	about 200,000 lbs.
Weight on drivers	about 132,000 lbs.
Tractive power	about 26,500 lbs.

It is expected that details of the construction and operation of locomotive will be published in a future issue as soon as the trial runs have been completed.

Comparative Tests of Steam and Oil-Electric Locomotive

The efficiency of the oil-electric locomotive—the most recent development in the motive power field, but now an assured success after years of experimentation—was strikingly demonstrated in a series of tests made by the Central Railroad of New Jersey during December.

At the Bronx Terminal in New York City a sixty-ton oil-electric, operating for 24 days during December, in 347 hours of locomotive service handled a total tonnage of 61,556 at a total fuel cost of $72.58. A steam locomotive, operating under almost identical conditions in December, 1924, in 24 days rendered 297 hours' service, and during this time moved a tonnage of 50,493 at a cost for fuel and oil of $349.46.

The oil-electric, in other words, handled 11,000 more tons than the steam locomotive and at a fuel cost of approximately 20% as compared with the steam engine. The cost of fuel per 1,000 tons handled was $1.16 for the oil-electric as compared with $6.92 for the steam locomotive.

The saving in fuel costs is only one of the many economies made possible by the oil-electric. It will make possible elimination of coaling plants, ash pits, turn tables, and expensive round houses and hostling services. Very little water is necessary, thus eliminating costly watering stations and troubles due to bad water conditions.

Use of the oil-electric locomotive would reduce locomotive maintenance costs by one-half: and each oil-electric, during the course of a year, would be able to render twice as many hours of service as are now obtainable from the steam locomotive.

The following statistics, as compiled by the Central Railroad of New Jersey, afford the first real comparison of the relative efficiency and operating costs of the oil-electric and a steam locomotive.

Comparative Operation—60-Ton Oil-Electric vs. Steam—Month of December, 1924, 1925:

	Oil-Electric 1925	Steam 1924
Number of days	24	24
Hours of locomotive service	347	297
Operating fuel consuming hours	318	297
Fuel oil used, gallons	1,038	...
Diesel lubricating oil used, gallons	25	...
Gasoline used	5	...
Engine oil used	5	5
Valve oil used	10	5
Star cup grease used, lbs.	1	..
Kilowatt hours generated	6,614	..
Coal used, tons	..	41
Number of floats handled:		
In	57	47
Out	57	46
Total	114	93
Number of cars handled		
In	947	775
Out	943	765
Total	1,890	1,531
Tons handled:		
Off float (net 19,908)	38,889	31,040
On float (net 3,766)	22,667	19,453
Total (net 23,674)	61,556	50,493

Includes tar weight of cars.

	Oil-Electric 1925	Steam 1924
Cost of operation:		
Fuel oil at $.05 per gal.	$51.90	...
Diesel engine lub. oil $.53 per gal.	13.25	...
Gasoline at $.145	.72	...
Water at $.01/10 cu. ft.	.03	$28.37
Engine oil at $.262 per gal.	1.31	1.31
Valve oil at $.53 per gal.	5.30	2.65
Star cup grease at $.07 per lb.	.07	...
Coal cost at $7.15 per ton	....	293.15
Coal cost handling	...	24.00
Total cost of fuel, coal, oil, etc.	$72.58	$349.46

DAILY OPERATING AVERAGE

	December Oil-Electric 1925	December Steam 1924
Hours of locomotive service	14.5	12.4
Operating fuel consuming hours	13.3	12.4
Fuel oil used, gallons	43.2	....
Diesel lub. oil used, gallons	1.04	....
Gasoline	Neg.	....
Coal used, tons	....	1.7
Kilowatt hours generated	275	....
Number of floats handled	4.75	3.87
Number of cars handled	79	64
Number of tons handled	2,565	2,104
Cost of fuel, oil, coal, etc., total	$2.98	$14.56
Cost of fuel, oil, coal, per 1,000 tons handled	1.16	6.92

OPERATING HOURLY AVERAGE COST

Fuel, oil, coal, water, etc.	$.228	$1.18
Per car on and off floats	.038	.228
Per ton on and off floats	.0011	.0069
Cost per KW hours	.0109	....
Number of tons handled per hour	193	170
Rate BHP hours per gal. lub. oil	3,820	....
Lbs. fuel oil per KW hour generated	1.13	....
Oil engine load factor	9.62%	....

Tractive Effort of Four-Cylinder Compound Locomotives

The method of determining the cylinder dimensions and efficiency of the four-cylinder locomotives built by the Hanover Machine Works for the Northern Railway of Spain is described in its house organ and will be of interest to American designers.

The points decided upon in advance were that there

should be a weight of 140,000 lbs. on the driving wheels and that these should be 69⅞ in. (1.75 m.) in diameter. Also that in the arrangement of the cylinders in accordance with the de Glehn system, the low pressure cylinders should be placed between the frames in order to secure a mass equalization or balance. While carefully considering the strength of the cranked axle, it was nevertheless possible, thanks to the width of the Spanish gage (5 ft. 6 in.), to accommodate the low pressure cylinders of 27.5 in. (700 mm.) in diameter. Then by using the ordinary ratio of 1 to 2.32, the diameter of the high pressure cylinders became 18.1 in. Both cylinders have the same piston stroke of 26.77 in (680 mm.) and the steam pressure was fixed at 16 atmospheres or about 235 lbs. per sq. in.

If these dimensions are taken for the calculation of the maximum tractive effort with a cut-off of 25 per cent of the stroke, the result will vary according to the formula and units used.

For example the German formula for the calculation of the tractive effort of four-cylinder locomotives is:

$$T = \frac{D^2 \times S \times 2 \times .85\ P}{(R + 1)\ W}$$

In which

D = Diameter of L. P. cylinders in centimeters
S = Stroke of piston in centimeters
P = Boiler pressure in atmospheres
W = Diameter of driving wheels in centimeters
R = Ratio of low to high pressure cylinder section

By substituting the metric measurements in this formula we have

$$T = \frac{70^2 \times 68 \times 1.7 \times 16}{(2.32 + 1)\ 175} = 15{,}600 \text{ kg.} = 34{,}320 \text{ lbs.}$$

By substituting the English measurements in the same formula, we have

$$T = \frac{27.5^2 \times 26.77 \times 1.7 \times 235}{3.32 \times 69.875} = 34{,}860 \text{ lbs.}$$

This is, as would be expected, an insignificant and negligible variation.

If the same calculation is made in accordance with the formula developed by the American Locomotive Co. we get a variation that is not quite so negligible.

That formula is

$$T = \frac{D^2 \times S \times P \times C}{W}$$

in which C is a constant that varies with the point of cut-off and the ratio of the low to the high pressure cylinder. For a ratio of 2.3 and a cut-off at 85 per cent of the stroke this constant is equal to .555. By substituting this and the other English measurements of the locomotive under consideration we have

$$T = \frac{27.5^2 \times 26.77 \times 235. \times .555}{69.875} = 37{,}786 \text{ lbs.}$$

This is about 11 per cent more than the tractive effort given by the German formula using the metric measurements and 8.1 per cent more than that given by the same formula using English measurements. So that a rough method of comparison is to remember to add ten per cent to the tractive effort of European four-cylinder compound locomotives in order to obtain the approximate rating that would be given them in this country.

Carrying the analysis further on the basis of the German rating we have a coefficient of adhesion of a little more than 4. This can be virtually raised by careful sanding at starting and while running. A tractive effort of 28,000 would give a ratio of 5, which with the weight of train ordinarily handled would rarely be exceeded.

With the ordinary loading tractive efforts of 22,000, 20,000 and 15,000 lbs. are common and these correspond to mean effective pressures in the cylinder of 78, 69 and 52 lbs. per sq. in.

According to the investigations of Strahl, Lihotski and others these pressures should be obtained with cut-offs in the high pressure cylinders ranging from 30 to 45 per cent.

New Passenger Equipment Installed and Old Equipment Retired

An example of the kind of progress steadily made by a progressive industry is to be seen in the report for the last quarter of 1925 covering passenger-train cars owned by the Class I railroads of the country. This report, just issued by the Car Service Division of the American Railway Association, shows that during the last three months of 1925 the following passenger-train cars were added to the equipment of the railroads of the country:

New all-steel cars	356
New steel under-frame cars	159
New or reconstructed wooden cars	79
Total	594

During the same three months the passenger-train cars retired were as follows:

All-steel	74
Steel under-frame	100
Wooden	975
Total retirements	1,149

In other words, almost the entire increase in new passenger car installations was in all-steel or steel underframe cars; and with the exception of 174 cars the retirements were all wooden cars. The net increase is 282 all-steel cars and 59 steel under-frame cars. The net decrease is 896 wooden cars.

The passenger-train cars on order as of December 31, 1925, were:

All-steel	1,136
Steel under-frame	10
Wooden	none
Total	1,146

When these cars which are on order are delivered, and are accompanied by further retirements of old cars, the percentage of steel equipment will be considerably increased, and that of the less modern equipment will be still further decreased. At the rate of progress which is now being maintained, all-steel and steel under-frame cars will in a few years outnumber all the wooden cars still in service. This, of course, does not mean that conditions on many railroads and on many branches will not justify the continued use of wooden cars.

On December 31, 1925, the passenger train equipment of the railroads stood as follows:

All-steel	20,937
Steel under-frame	9,359
Wooden	23,701
Total	53,997

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The Weight of Superheated Steam

For many years we have had very complete tables giving the properties of saturated steam, so that the data for calculations were readily available. The necessity for similar information regarding the properties of superheated steam has been pressing more and more heavily upon us ever since its introduction into locomotive and steam turbine work. A good deal of work is the formulation of steam tables at the higher pressures has been done by the steam research committee of the American Society of Mechanical Engineers, and the data obtained were placed at the disposal of the turbine engineering department of the General Electric Co. by whom a very complete table of the specific volumes of saturated and superheated steam has been worked out.

The steam chart thus developed is based upon the Harvard throttling experiments, which involved the use, also, of the Knobland specific heat determinations.

The results of the work by the General Electric Co. have been presented in the form of an elaborate table of the properties of superheated steam. This table, as published, gives the number of cubic feet per pound of superheated and saturated steam through a range of pressures from one pound to 1,200 lbs. per sq. in., absolute, and for a superheat from zero to four hundred degrees Fahr. The pressures rise by increments of one pound to 150 pounds per sq. in.; thence by increments of two pounds to 250 pounds per sq. in.; by increments of five pounds to 400 pounds per sq. in.; by increments of ten pounds to 750 pounds per sq. in., and finally by increments of twenty-five pounds to the upper limit.

The range of the superheat is covered by increments of ten degrees each from the zero to one hundred degrees, thence by increments of twenty degrees to 200 degrees and then for the two final figures we have the 300 and 400 degree indications.

If the column of temperature in degrees Fahrenheit be compared with a similar column of the Porter determinations as given in Kent's Pocket Book, the two will be found to be in very close agreement throughout the lower ranges of pressures, although there is some variation. The temperatures of the new tables fluctuate a little below the Porter table until a pressure of 20 lbs. per sq. in. absolute is reached, after which they are definitely higher by a fraction of a degree. The maximum being 0.3 that is gradually reached and then held for some time until a pressure of 220 lbs. per sq. in. absolute is attained. After which the difference decreases until at 375 lbs. the two tables are in accord, after which the figures of the new table fall off comparatively rapidly relatively to the old one, until at 1000 lbs. which is the limit of the latter the difference is 1.7 degrees. So far as the saturated steam table is concerned there is not much change from that which we have been using. The chief value, then, lies in the completeness and range of the superheated steam table, which will be of great value in supplying greatly needed data.

In presenting the table it is distinctly stated that it is not to be supposed that it represents the final word on the properties of steam in the region which it covers, and it was developed because of the urgent need for the data which it contains. It is expected that further information yielded by the steam research program of the American Society of Mechanical Engineers may serve to enlarge or modify the table. Meanwhile it "will be of service at a development of the most extensive and dependable empirical data that have yet been published on steam at high-pressure."

Why Not Use the Sandblast

For many years we have been taught that when paint is to be applied to a metallic surface with the expectation of securing the best protective results, that surface should be first cleaned of all dust, dirt and grease. The statement has been accepted, never disputed, and rarely followed. We see metallic structures being repainted year in and year out, but those of us that have ever seen a proper method of cleaning applied are few and far between; while those who have would find the digits on their hands more than sufficient to account for every instance that has been brought to his or her personal attention.

When surfaces other than the outsides of houses are to be painted there is usually some pretense of cleaning them but it is almost invariably a mere pretense. The use of a dust brush is the ordinary method, though for very dirty metallic surfaces the wire brush is not uncommon But these don't really clean, they merely emulate the motions of a hasty housewife by giving a lick and a promise And any sort of an examination of the surfaces so prepared will show them to be far from being in an ideal condition to receive a coat of paint.

It is strange that with this almost universal disregard of precept there is no authentic information as to the reason therefor. If it has been tried with sufficient frequency to have proven that it does not pay, who has made the trials?

A few years ago a superintendent of motive power of one of the southern railroads installed a plant for sandblasting tender tanks before painting. It was continued in use for a few years and then abandoned.

The subject is brought to mind by a report on the tests being made by the American Society for Testing Ma-

terials which says that "the tests seem to indicate that the most rapid deterioration of paint occurs where applied over a badly rusted surface. The tests on new steel indicate that painting will preserve sandblasted or pickled surfaces." Then again, "the tests on old panels seem to indicate that there is little advantage in the application of so thorough a method of cleaning as sand-blasting; whereas one panel half cleaned by hand and half by sand-blasting shows a decided superiority in the sand-blasting method." From which the conclusion is drawn that "there must be some intermediate point in surface condition between 'the two that' would determine the method required for the best results."

As it stands our faith is not strong enough to drive us to act, and yet we knowingly persist in a practice that is unsatisfactory because ——. Well, who knows?

The Use of the X-Ray in the Inspection of Metals

At the last meeting of the American Society for Testing Materials a committee report was presented on X-ray Metallography in which the methods and results attained with that method of inspection were fully discussed.

The application of the method has, thus far, been quite limited and the results achieved, so far as they relate to foundry problems, have been for the most part obtained in the testing laboratories of Watertown Arsenal where an X-ray section was installed in the fall of 1922 for metallurgical research and radiographic testing. Due to the fact that this was a pioneer laboratory the first problem of importance was the development of a suitable laboratory technique. In this study it was found that the thickness of metal that could be successfully radiographed was for practical purposes a linear function of the voltage across the tube up to 200,000 volts, the current through the tube and the exposure time being constant. The practical limit of thickness that could be radiographed was found in the case of steel to be about 3 in., in which thickness a cavity 1/16 in. in diameter could be detected. Pictures through 3 in. were obtained with 30 minutes' exposure. The maximum thickness of steel radiographed was 4 in., the pictures being obtained with seven hours and forty minutes' exposure. Since that time, the practical limit has been raised to 3½ in. thickness of section for favorably shaped steel castings and a picture through 4.1 in. of solid steel has been obtained with one hour and thirty minutes' exposure.

The next problem that presented itself was the problem of diagnosing films. It was necessary to find out what the spots on the films meant. To get at the information required, castings found by the X-ray tests to be defective were cut up and revealed defects were compared with their images in the negatives. This work was enlarged to include a systematic study of casting defects. As a result of the investigation it was found possible to diagnose the defects found in the film negatives with a fair degree of certainty. In many cases the defects could be correlated with definite causes.

In foundry control testing the radiographic method has been used successfully to develop proper casting technique in the Watertown Arsenal and in some commercial foundries. It is probable that this application will be the most important one for metal radiography. This use forces definite study of specific defects with consequent specific education of foundry personnel. This study has resulted in general improvement in casting quality and in a reduction in the percentage of rejected castings.

In the field of inspection testing, the method has been employed successfully both in this country and abroad. Much ordnance material such as aeroplane parts, fuses for shells, and similar small pieces were examined in this way in England during the war. Carbon electrodes, built up mica, turbine blades and various other articles of manufacture have been inspected by the radiographic method in this country but the more spectacular applications in the past two years have been in the inspection of heavy castings. An illustrative example of this use is the examination of the turbine shell, steam line, and control valves of a 1200 lb. per sq. in. steam pressure installation in a modern superpower electric plant. In this case, the value of the service into which the castings entered was such that the X-ray tests were regarded as necessary insurance. In these tests some castings were rejected which would have passed any ordinary tests. It is probable that radiography will find an increasing application in inspection tests where, as in this case, the loss from breakdown would greatly exceed the cost of the tests.

Further development in X-ray apparatus is needed. Higher voltage tubes should be developed. There is probably a limit beyond which higher voltages would not be advantageous, but that limit has not yet been reached. A million-volt tube should be able to test sections 10 in. thick.

The greatest present limitation to a more extensive use of radiographic tests is the cost and this is due partly to the lack of flexibility of the apparatus. X-ray pictures cost at present from one dollar to five dollars apiece and it takes sometimes forty pictures to cover an important casting. It is probable that radiography will always be expensive as a method of inspection. Its economical application to foundry control testing seems possible, but here also its value will depend on the individual problems of the foundry. With the present rapid evolution of the mechanical appliances of industry there is an ever-growing demand on structural units for increased strength and dependability; metal radiography should be helpful in this connection.

Anyone interested in a more detailed study of metal radiography will find some helpful references at the end of this report.

British and American Railways

To the Editor:

A great deal of the public discussion of railways in America relates to freight rates and the various other factors which affect the industries of the country. Passenger services receive very little publicity in the press, except what is bought and paid for.

Accustomed as American railroad men are to these conditions, it comes as something of a surprise to learn that a considerable number of people in Great Britain take a lively interest in the "home" railways, which has a "sporting" element in it that is totally lacking in America. To what extent this popular interest helps British railways I am not prepared to say; though it seems reasonable to suppose that the net results must be favorable. The distinctive colors used in the finish of motive power and rolling stock doubtless have value for advertising purposes and tend to focus public attention upon "crack" express trains and notable locomotives.

Just now, a merry controversy is in progress over the relative merits of British and French express trains, which, as it may have some points of interest to American railroad men, is worthy of notice in the American trade press. Starting in the daily press, this controversy ultimately reached the House of Lords and subsequently bounced back into the railway periodicals where certain of the more advanced students of operating methods are now threshing it out. These students favor an increase of

speed on British railways which will put them abreast of the reported achievements of the French railways. The British railway officials are "standing pat," as we would say, and maintaining that express services in Britain are fast enough. In this attitude they seem to be justified, since the evidence in favor of French railways is not entirely convincing to impartial observers. As public reaction to this controversy may hit us in due course, we can afford to examine it.

In the first place, the records show that a goodly number of British express trains are run at an average speed of over 55 m.p.h., and that one or two are operated at over 60 m.p.h. "start to stop." Considerable numbers of others average over 50 m.p.h. These are very good figures—from an American point of view, at all events—and not to be sneezed at even in France!

"They order," said Laurence Sterne, "these things better in France." But that was many years ago, and the remark was not concerned with railways!

In the second place, the records likewise show that train-loads on, for example, the Great Western Railway of England are not inferior to those on, say, the Nord of France. The days of feather-weight express trains have long since gone in England, and a load of 500 (long) tons behind the tender is now the order of the day, with 550 as a possibility of the near future. The evidence shows that trains of ten to fourteen of the heaviest "bogie" vehicles, packed to capacity, roll out of Paddington every day behind engines which, for concentrated efficiency, are second to none. Express train loads in the "up" direction are almost as heavy, the "consist" being eight to a dozen vehicles.

With reference to grades: It appears that the profile of the Nord is rather more unfavorable from certain points of view, than that of the Great Western; though this aspect of the matter is often unduly stressed.

What is being thrust into notice most, however, is the fact that French railways are partial to the de Glehn compound. This move is a mistake, since neither British nor American railways have the remotest intention of ever adopting this design. It has been tried both in England and America, and definitely rejected. Further touting of this type is, therefore, ill-advised, to say the least.

Since, in the present controversy, the Great Western has been cited as a suitable British railway for purposes of comparison, a few words about its express engines may not be out of place.

For upwards of twenty years, a great deal of the express work on this line has been done by 4-6-0 engines of the famous "Star" class. The first of these engines was named "North Star," in honor of a celebrated engine of very early times. The modern "North Star" had four single-expansion cylinders, each $14\frac{1}{2}$ x 26 inches, 80-inch drivers, and a weight, without tender, of 169,200 lbs. Subsequently, the cylinder diameter on this and other engines of this class was increased to 15 inches. As the boiler carries a working pressure of 225 lbs. per square inch, the tractive effort was thus 27,800 lbs., a splendid result for a ten-wheel engine of this weight.

A new 4-6-0, known as the "Castle" class, is even more powerful. By increasing the cylinder diameter to 16 inches, the tractive effort is raised to 31,625 lbs. Steaming capacity is assured by the provision of a somewhat larger boiler than is used on the "Star" class. Outside steam pipes and a more commodious cab constitute the other improvements.

Mr. C. B. Collett, the C. M. E. of the G. W. R., intends to rebuild all the "Star" as "Castles," according as the former come due for heavy repairs. Ultimately, therefore, the G. W. R. will have a remarkable group of 4-6-0 express engines. I use this term advisedly, since the power of this class is enormous in proportion to total weight, and taking into consideration the important fact that it was designed for high-speed service. (Some 4-6-0 engines in America are rather powerful, but it must be remembered that their drivers are relatively small).

Coming, finally, to actual schedules and rates of speed, we might as well quote the official figures.

The fastest train in Britain is one which, I believe, originates at Cheltenham. Anyhow, it stops at Swindon, leaving there at 3.45 P. M. and running the 77.3 miles thence to London in 75 minutes, or at the rate of 61.8 miles per hour. Let the critics laugh that off, if they can!

Other G. W. runs of considerable merit are those between London and Birmingham, 110.6 miles; and London and Bristol, 118.3 miles; both covered in two hours flat.

London to Cardiff, 145.1 miles, in two hours and forty minutes, is rather good going, especially on a busy line.

Then, the famous non-stop run, London to Plymouth, 225.7 miles, in four hours and seven minutes is still a creditable performance, particularly when the hilly nature of the western end of the line is considered.

It would take too long to analyze further the very fine services of the G. W. R., but I think that enough has been adduced to show that they will take a lot of beating. I may add, however, that engines of the "Star" class have exceeded 90 m.p.h. in actual service.

Train Hauled by 4-6-0 Type Locomotive on the Great Western Railway, England

The photograph presented herewith shows an up Cheltenham express train handled by "Bath Abbey," one of the later "Stars." Ten vehicles are in view, the first of which, a "luggage van," bears a striking resemblance to our own baggage cars. The second vehicle is one of the old coaches. The balance of the train is made up of modern stock.

Railways, both at home and abroad, have had occasion to complain of competition of autos. Perhaps the answer to that problem will be found in better and, where needed, speedier railway service.

Newton Center, Mass. ARTHUR CURRAN.

Snow Melting Device for Locomotives

The Boston & Maine Railroad placed in service recently a device to melt snow and ice on switches, turnouts, and around interlocking and equipment. It consists of a pipe line attached to the steam dome of the locomotive, and leading to a point below the engine pilot. A valve is provided, with connection into the cab for regulating a supply of steam, and the section of pipe attached to the pilot is fitted with nine nozzles made of $\frac{1}{2}$ in. pipe. The locomotive is run over switches, turnout, etc., at a rate of speed of from two to three miles an hour, and live steam is directed through the nozzles on the snow covered surfaces.

Three-Cylinder Locomotives on the Wabash Railway*

By W. A. Pawnall, Mechanical Engineer, Wabash Railway

About a year ago 50 heavy Mikado type freight locomotives were built for the Wabash Railway by the American Locomotive Company. Before ordering these 50 engines considerable thought was given to the advantages claimed for the three-cylinder type. The performance of three-cylinder engines in service was investigated and it was decided that while 45 of the 50 would be of the usual two-cylinder type the other five would be of the three-cylinder type.

The advantages which were expected from the three-cylinder engines as compared with the two-cylinder were briefly as follows:

Reduction of stresses on pistons, crosshead and rods due to dividing the load among three sets of parts instead of two. Less severe strains in main frames axles and other parts of the locomotive because of more even distribution of the load or work transmitted from the cylinders through the axles, rods, wheels, etc. Less reciprocating weight to counterbalance, resulting in lessening the hammer blow on the rail as well as side thrust of "nosing" of the engine. Less damage to freight cars due to smoother starting of heavy trains.

Increased tonnage per train or increased speed with the same tonnage, and a saving in fuel and water. Less slipping of the engine when starting heavy train or with slippery rail conditions. Decreased track and bridge maintenance due to lower dynamic augment and nosing of engines.

In preparing specifications for these engines the design of some heavy Mikado built in the previous year was closely followed, only such major changes being made as were necessary for the three-cylinder type. Arrangements were made for the other 45 to be readily convertible if so desired at some future time, to three cylinder engines with a minimum amount of change and expense. The principal change from the older, or class K-3 engines, consisted in increasing the distance between the second and third driver 13 in., the distance from the center of the cylinder to the engine truck wheel 4 in., and from the rear driver to the trailer 6 in., this last being due to an increase of 6 in. in firebox length rather than to any feature of the three-cylinder design. The 13 in. increase in distance between the second and third drivers was necessary in order not to have too short a middle main rod as well as to get proper angularity of this rod and clear the first and second axles. The engine truck was advanced 4 in. in order to provide necessary space in front for the valve gear for the center cylinder of the three-cylinder engine. The resultant increase in engine wheel base over the older engines was from 37 ft. 2 in. to 39 ft. 1 in., or 23 in. The main rod length was increased 10 in., and it was necessary to offset the center of the second driving axle in order to provide proper clearance for the center main rod.

These increases in wheel base cause little difference in appearance between the two and three-cylinder types. If at some time in the future the merits of the three-cylinder type justify conversion of the two-cylinder engines, it will be necessary to change only the cylinder, crossheads, valve gear, second and third driving axles and add necessary parts for the additional center cylinder.

Mikado Type Locomotive Class K-3 of the Wabash Railway Placed in Service in 1924

These three designs of engine will be referred to as follows; class K-3 covers the two-cylinder type put in service early in 1924; class K-4 covers the 45 two-cylinder type and class K-5 the 5 three-cylinder type, placed in service in 1925. The K-3 and K-4 have 27 in by 32 in. cylinders while the K-5 has the two outer cylinders 23 in. by 32 in. and the center cylinder 23 in. by 28 in.

The K-4 and K-5 carry 5 lb. more boiler pressure than the K-3, and the tractive force developed are K-3, 60,416 lb.; K-4, 61,965 lb; K-5, 64,637 lb.

For comparison the following table shows the principal dimensions of the three classes:

	Two-cylinder type K—3	Two-cylinder type K—4	Three-cylinder type K—5
Cylinder diameter and stroke	27"x32"	27"x32"	2, 23"x32" 1, 23"x28"
Steam pressure	195 lb.	200 lb.	200 lb.
Diameter of drivers	64 in.	64 in.	64 in.
Tractive force, lb.	60,416	61,965	64,637
Factor of adhesion weights, lb.	3.94	4.01	3.87
Drivers	238,000	248,450	251,215
Front truck	31,000	30,810	33,110
Trailer truck	56,000	54,470	56,165
Total engine	325,000	333,730	340,490
Tender loaded	196,500	194,500	194,500
Engine and tender	521,500	528,230	534,990
Cylinder horsepower	2,558	2,624	2,856
Heating surface, sq. ft.			
Firebox	273	309	309
Arch tube	32	32	32
Tubes	2,660	2,660	2,660
Flues	1,224	1,224	1,224
Total	4,189	4,225	4,225
Superheating	1,051	1,051	1,051
Grate area, sq. ft.	66.7	70.2	70.2
Mechanical stoker	Duplex	Duplex	Duplex

It will be noted that the K-5, with a slightly greater weight on drivers than the K-4 has an increase in tractive force of 2,672 lb., or 4.4 per cent and a noticeably lower

*Paper presented at the Chicago Section meeting of the American Society of Mechanical Engineers, Feb. 24, 1926.

factor of adhesion. Thus, advantage has been taken of the feature of more even turning movement of the three-cylinder type of engine to use a lower factor of adhesion and obtain an increased tractive force or hauling capacity at slight increase in weight of engine and without having a "slippery" engine. The results in actual service will be touched on later.

The five three-cylinder engines were place in service during April and May of 1925, and were assigned to fast merchandise freight trains running between St. Louis and Chicago. A good proportion of the distance is double track road, the ruling grade from St. Louis to Chicago is 0.6 per cent for the first 25 miles and 0.4 per cent for the balance of the way, and is 0.8 per cent, 0.7 per cent and 0.3 per cent from Chicago to St. Louis. Usually the heavy business is coal northbound handled in 5,000 ton trains by 2-10-2 type engines, but the merchandise trains are necessarily of comparatively light tonnage in order to make required speed, particularly to Chicago, where early morning deliveries must be made. Their average speed in motion is about 27 miles an hour. No attempt is being made to make long runs with these engines, and they are operated from East St. Louis, Ill., to Decatur, 108 miles, and from Decatur to Chicago 168 miles. The northbound trains leave East St. Louis early in the evening and are due in Chicago 276 miles away at four o'clock the next morning. A few examples of these run with the three-cylinder engines are shown here.

From	Cars	Tons	Miles	Time, hrs. and m'ns. Between ter-minals	Delay	In motion	Speed, m.p.h. In motion	Between ter-minals
St. Louis to Decatur	50	2,019	108	3:50	6	3:44	28.9	28.2
Decatur to St. Louis	75	2,430	108	4:53	54	3:59	27.1	22.1
Decatur to St. Lopis	60	1,991	108	3:50	27	3:23	31.9	28.2
Decatur to Chicago	40	1,675	168	6:40	55	5:45	29.2	25.2
Decatur to Chicago	50	1,874	168	7:40	1:48	5:52	28.7	21.9
Decatur to Chicago	52	2,046	168	6:32	1:25	5:07	32.8	25.7

If the trains are late out of the terminal or meet with unusual delays, they make considerably higher speed than shown in this table in order to get in on time. I rather hesitate to use the term "high speed" here, for undoubtedly some of the railroad men present have in mind right now some faster trains on their roads. However, most of the roads have some time freight trains that they watch particularly, and if the conditions are in any way similar to ours, the performance figures herein furnished may give basis of comparison.

During 1924, these same time freight trains were handled partly by the class K-3 engines, which are, as already shown, very similar to the three-cylinder engines and by our class L-1 engines, which are the 2-10-2 type with 71,485 lb. tractive force. Fuel performance records are kept by individual engines and engineman, the amount of coal used being taken from engineman's coal tickets, and the train tonnage, etc., from the car accountant's records. Information taken from these fuel records and covering the performance of the three-cylinder from May to November, 1924, and for the two-cylinder engines for the same trains and corresponding months in 1925 shows the following comparison.

Class	L—1	K—3	K—5
Type	2-10-2	2-8-2	2-8-2
Cylinders	two	two	three
Total trips	368	677	1,078
Average tons per train	1,937	1,714	1,853
Lb. coal per 1,000 ton miles	136.8	118.6	113.6
Per cent saving, three-cylinder Class K-5 over two-cylinder Class L-1	....	....	16.96%
Per cent saving, three-cylinder Class K-5 over two-cylinder Class K-3	....	....	4.2 %

These records show that the three-cylinder class K-5 engine handled time freight trains averaging 8.1 per cent heavier than the trains handled by the class K-3 two-cylinder engine of similar proportions during the corresponding period of previous year, and at a coal consumption of 4.2 per cent less on the ton-mile basis. The average train for the three-cylinder class K-5 was 55 cars, as compared with 45 cars for the class K-3. As compared

Mikado Type Locomotive Class K-4 of the Wabash Railway Placed in Service in 1925

with the 2-10-2 type, the three-cylinder engine fuel performance was 16.96 per cent better. The less favorable fuel showing of the 2-10-2 engine was probably due in a measure to these engines being somewhat heavy for this particular class of service which would result in an increased fuel rate on the ton-mile basis. However, the three-cylinder engines did the time freight work previously done by the two cylinder 2-10-2 type and class K-3 engines, and at a fuel saving of 10.4 per cent over the combined performance of the two-cylinder engines. There would not be so much difference in point of cut-off between two and three-cylinder engines in fast freight service since with both type the cut-off is comparatively light, but with full tonnage trains the three-cylinder engine would work at materially less cut-off resulting in a greater per cent of fuel saving than shown here for fast freight service.

The figure of 113.6 lb. of coal per 1,000 ton miles may look rather high in the light of not infrequent instances of 60 to 80 lb. per 1,000 ton-miles in drag freight service, but it should be remembered that the high speed demanded in the time freight service and the fact that the average train is perhaps less than 50 per cent of the dead freight tonnage rating are against a favorable fuel performance. Our records given here are for similar sevice and show favorably for the three-cylinder engines.

These engines have now been in continuous service for about nine months. The opinions of the road foremen

of engine and fuel supervisors have been asked for from time to time and I quote a few:

"At high or low speed the three-cylinder engine get the train going quicker and rides better than the two-cylinder engine."

"It is easier for a three-cylinder engine to start a train without taking slack and therefore cause less damage to draft gears."

"Any train that can be started can be run at a more uniform rate of speed and handled better over the hills."

"There is a saving in fuel and water over the two-cylinder engine."

"Train can be handled at 33 to 35 per cent cut-off where a two-cylinder would have to be worked at or near 50 per cent cut-off to handle same train."

Although the three-cylinder engines have been used mostly in this fast freight service, tonnage ratings for drag freight have been established from dynamometer car tests. A comparison of the rates thus established for the two-cylinder and three cylinder engine is given here.

From	To	Ruling grade %	Adjusted rating tons: Two cyl.	Adjusted rating tons: Three-cyl.	Car factor	% Inc. three-cy. over two cy.
E. St. Louis	Worden, Ill ...	0.6	4,130	4,360	7	5.6
Forest, Ill.	Chicago	0.4	4,990	5,210	11	4.4
Chicago	Brisbane, Ill....	0.9	3,260	3,585	5	10.0
Brisbane, Ill.	Decatur, Ill....	0.7	3,670	4,175	6	13.8
Mt. Olive, Ill.	E. St. Louis...	0.3	6,240	6,510	12	4.3

The three-cylinder engines have 4.4 per cent greater tractive force than the two cylinder, and where the ruling grade was 0.4 per cent and the train was kept moving the tonnage rating increase was the same as the increased tractive force that is 4.4 per cent. However, on the steeper grades, which on these districts are usually momentum grades, the three-cylinder engine seemed to keep the train moving at a better speed on the first part of the hill, and it was possible to establish ratings somewhat greater than the two-cylinder engine ratings than the difference in tractive force justified. For example the rating from Chicago to Brisbane was increased 10 per cent and from Brisbane to Decatur 13.8 per cent.

The three-cylinder engine admittedly possesses advantages from the mechanical and operating standpoint, but a serious question in many minds was whether the additional maintenance or increase in mechanical failures due to the extra parts and unusual features of design would not more than offset these other advantages. Past experience with engines having relatively inaccessible parts has been unfavorable in that these parts did not receive proper attention resulting in road failures and ultimately rather heavy maintenance costs.

Although our five engines of this type have only been in service about nine months, and have not yet been in the shop for classified repairs, there has thus far been with the exception of some middle main rod trouble, no more running repair work than on similar size engines of the two-cylinder type. The following table shows the mileage these engines have made each months in freight service, and these mileages are good evidence that the engines have not been spending much time in enginehouses undergoing repairs.

Monthly Mileage of Three-Cylinder Locomotive of the Wabash

Month	No. 2600	No. 2601	No. 2602	No. 2603	No. 2604
May	5,572	3,598	5,205	3,260	....
June	4,504	2,978	5,166	4,552	4,578
July	4,968	4,641	4,398	4,384	5,160
August	5,664	4,644	4,992	4,532	2,668
September	4,464	4,798	4,764	4,769	2,182
October	6,264	5,028	4,522	4,854	3,552
November	5,616	3,840	4,376	4,684	4,800
December	5,002	4,850	3,360	4,560	4,530
Total	41,054	34,377	36,983	35,686	27,470
Av. per month	5,132	4,297	4,623	4,461	3,924

Average per month per engine, 4,492 miles.

Twelve of the two-cylinder engine class K-4 averaged 4,164 miles per month on the adjacent division.

The matter of suitable middle main rod design, particularly the back end, has given the builder some concern. After our engines had been service about six weeks we had some reports that the back end of the middle main rod was pounding. We had had more or less success with the use of the floating bushing for the middle connection of side rods and had decided to use this type of bushing for the back end of the middle main rod for the three-cylinder engines. The bushing was applied in three sections, the back end of the main rod being necessarily of strap construction since the solid back end main rod could not be applied to the crank axle.

The sections of the brasses first applied were 1/16 in. between the ends, or a total of 3/16 in. for the three openings, and the brasses were also applied so as to allow ⅛ in. side play. The result of this side play and the openings between the ends of the brass was more or less side slap and noise, which contributed to the complaints about rods pounding. The strap was attached to the rod with three bolts, and we had little trouble on account of these bolt shearing and had one actual engine failure due to broken strap. However, this failed strap was traced to a defect in material. In view of this experience, we were not entirely satisfied with the floating bushing application, and it was decided to apply sectional brasses similar to the usual sectional brass used on the outside main rods. Two of the first engines were thus equipped. The other three engines continued to use the floating bushings, but with only 1/32 in. of lateral play and with the ends of the section 1/32 in. apart instead of 1/16 in., giving a total end clearance of 3/32 in. instead of 3/16.

In the meantime we noticed more or less trouble with leaking of the center cylinder piston rod packing, and investigation indicated that this was due to water in the

Three-Cylinder Mikado Type Locomotive Class K-5 Placed in Service in 1925

cylinder. There were two-cylinder cocks for the center cylinder, and with this installation it was found that water not only accumulated in the passage leading to the cylinder, but could also accumulate in the back end of the inclined center cylinder. The cylinder cock location was changed to take care of this accumulation of water. The front cylinder cock was left in its original position. The back cylinder cock hole was plugged and the cylinder cock relocated so as to take the water from the lowest point of the center cylinder. The cylinder cocks are air operated so as to do away with the objection of long cylinder cock rigging from cab to cylinder.

Since making the change in cylinder cocks we have had little or no trouble with any of the main rods or with piston rod packing leaking, whether the engines are equipped with the sectional brass or with the original floating bushings. However, our records show that thus far the floating bushings have been renewed at an average mileage of 9,600 and frequently it has been advisable to renew the back end rod bolts at about the same interval. The two engines with the sectional brasses have had the brasses reduced on an average, once every 15,000 miles, the reduction each time being only 5/64 in. In view of the fact that floating bushings have to be renewed four or five times between shoppings, whereas the sectional brass may last from shopping to shopping with two or three "reductions," the expense of middle main rod brasses is considerably in favor of the sectional brass. This should not be construed as being against the floating bushings for outside rods, but is simply giving results of our experience with different types of back end main rod brasses for center cylinder of our three-cylinder locomotives. We are inclined to favor the sectional brass rather than the floating bushing, but believe that what trouble we had with the main rod was probably due to water rather than to any improper or impractical design of main rod parts.

Summing up our experience with five locomotives of the three cylinder type, I would say that:

1. Maintenance will not differ materially from the two-cylinder type. It will possibly be less over a long period.

2. From the standpoint of train operation the three-cylinder engines will do better than the two-cylinder type

3. The three-cylinder engine will make a moderate saving in fuel and water in fast freight service, probably more in drag freight service.

4. Enginemen and supervisory forces are, in general well satisfied with the three-cylinder locomotives.

Railroading and the Engineer

Address of S. P. Bush, President, Buckeye Steel Castings Co., at the Altoona Regional Meeting of the American Society of Mechanical Engineers.

The history of transportation and industrial development in America is so well known to you that it is unnecessary to review it, but suffice it to say that the entire economic development of the country has been largely dependent upon it, and with continuing growth of the country must necessarily become increasingly dependent upon it.

The complexity of economic conditions, not only in America but throughout the world, with the competitive struggle increasing in intensity, demands more and more the broader vision, more comprehensive understanding, and greater interest in the whole structure, to the end that we may continue to progress and maintain that balance and stability on which progress depends to a very large extent.

Originally, and before the days of the application of steam, ours was a maritime country and enjoyed worldwide preeminence as such for many years. The trained engineer played a very small part in the construction and operation of our sailing ships, in which was transported approximately 60 per cent of the world's commerce. With the introduction of the steam engine Great Britain assumed the leading position, and the maritime interests of this country were gradually reduced to very small proportions. Subsequently the country became mainly agricultural, but of recent years great changes have taken place.

The real development of transportation and industry in this country may be said to have begun about the time of the Civil War, or about 60 years ago. This was and previous experience made it clear that it was essential for this country to be independent of the rest of the world in the production of all those things that are essential to the national defense. To this end a protective tariff policy was inaugurated by congress so that natural resources and manufacturing might be stimulated to profitable development.

The total wealth of the country in 1900 was estimated at 88½ billion dollars. It was estimated in 1912 at 320 billion dollars, which is sufficient to indicate how rapid and extensive our economic development has been.

At the present time the railways of the country, either directly or indirectly, consume 25 to 30 per cent of all its steel production, and about 25 per cent of all the bituminous coal it mines. They require a greater variety of commodities and service than any of our economic groups. They operate two and a half million freight-equipment cars and transport annually 2,300,000,000 tons of commodities and 950,000,000 passengers.

A division of the people into definite economic groups as a result largely of the transportation development, has brought to the front and to some extent visualized to them the dependence of each group upon the others, and particularly the fundamental importance of transportation as a basic industry.

Industry, by which is generally meant manufacturing, as the result of governmental policy and the development of transportation in this country has now become the greatest as measured by the value of production, and we are today the leading industrial nation of the world.

But while the engineer has done much toward the development of industry, particularly in recent years, I think it is within the truth to say that the larger part of our development has been accomplished by men who have not had the advantage of such institutional education as the country has afforded in recent years. Today the scientist and engineer are indispensable to most of our industrial and transportation development, which offer fertile fields of endeavor, both technical and administrative.

In this connection it may be of interest to you to know that on the suggestion of several industrialists, the National Industrial Conference Board, one of the most important research bodies in the United States, is now engaged, through a committee of industrialists and scientific educators, in ascertaining in what way engineering schools

may assist in the better training of men for industry, and in what way industry may assist engineering schools. Many industrialists feel that graduates from technical schools have not received quite the right training or been given quite the right outlook. It has for a long time been a question as to how this might be done, and it is the purpose of this board to ascertain, if possible, the best course in this respect. It is significant to note that this industrial-research body is supported liberally and exclusively by industry, and has in its governing body and membership a number of engineers who deal almost entirely and in a broad way with the economic aspect of all the groups that go to make up the national life, to the end of aiding economic and social progress and stability. This is a matter in which I am sure you must have a very considerable interest.

In this connection I might mention that the Pennsylvania Railroad and some few of the larger industries in this country have for many years maintained a special apprenticeship course for graduate engineers, to the end of developing superior men, both technicians and administrators, and with excellent results; but since the World War there seems to have been considerable disinclination on the part of graduates to this rougher preliminary service, much, I believe, to their own disadvantage and to the best interest of industry and the engineering profession.

As further illustrating the wider field open to the engineer, I recall that shortly after the war, when the economic condition of industry in this country was chaotic and badly out of balance, the probability was that industry would have to face more severe competition and operate with greater economy than heretofore, Secretary Hoover, himself an engineer, desiring to ascertain the real facts in the case and what might be done to put industry on a better basis, appointed a commission of engineers to investigate and report; and the results of this investigation some of you are probably familiar with. It was significant, although not extraordinary, that he should have selected engineers to undertake this task, for the engineer's work is very largely that of honestly and truthfully finding, recording, and facing facts. It was probably not within the scope of this commission's work to relate the conditions they found in the industrial field with those of others, but I think it must be clear that this relation not only exists but is at the bottom of our economic fabric, and it would seem that the engineering profession as a group, in its own interest, as well as that of the general welfare, might interest itself more widely in the national aspect of this relationship. Reduced to the smallest possible terms, the substance of this commission's report was the elimination of waste through specialization, standardization, and stabilization.

When Samuel Rea was president of the Pennsylvania Railroad he said that he believed the opportunities for young men to succeed in railroading are better today than ever: that a higher class of mental and physical equipment for leadership is required than 50 years ago; that while the development of railroads might not be in opening up new territory, the necessity for new and better methods is more urgent than ever. Revenues must be increased, expenses reduced, waste eliminated. No branch of the service is freed from the necessity of invention and progress of that character. The same may be said of industry.

If I were to suggest to any group one thing more needed than anything else at the present time, and which I believe will be required at no distant day, it would be a broader vision and a far wider consideration of all the groups essential to development in the future commensurate with that of the past. All groups heretofore have been too prone to concentrate their interest on their own particular problems, and have failed to realize the economic dependence of one upon another.

This is directed particularly to the administrator in general, but I would point out to the engineer as well, that the field of his endeavor for his own material welfare must necessarily be restricted and progress retarded unless each group exerts some influence in effecting the economic welfare of all the other groups by discouraging those proposals and efforts—sometimes enacted into law—which put one group or another at a serious disadvantage or gives one group an undue advantage over others.

Mr. Rea, in the statement to which I have referred, points out that the greatest stride in the railway transportation industry in the matter of second finance and service took place between the years 1899 and 1907, when railway management was far less restricted than at present. Since 1907 railway development has been seriously retarded until recently, through the application of much injudicious governmental policy. He states that in all business questions affecting the railroads he feels sure that the best satisfaction would be given to both railroad owners and the public if the process of interfering with the responsibility and judgment of managements should be halted and public regulation used as an impartial medium for adjusting or avoiding difficulties between railroad users, railroad owners, and the managers, with a view of providing service without discrimination and at the lowest compensatory rates.

If transportation cannot be conducted successfully and profitably, the engineer and industry will have a very meager field of endeavor; and it would seem that the maintenance of the transportation industry on a sound and profitable basis is a matter that should concern us even more than some of the other technical problems to which we devote so much of our time and interest.

As illustrating the matter, I call your attention to the fact that from 1912 to 1924, inclusive, the Class I railroads of this country, representing a total of 235,000 miles or approximately 95 per cent of all the railroads in the United States, were not able to earn as a whole except in one year, the 5¾ per cent on appraised values established by law as a fair return. Covering a period of three years after government operation, which was relinquished at the end of 1919, the average earnings were but 2.36 per cent. At the present time conditions are much improved as the result of the most highly efficient management and operation that the railways have ever known, and because of a substantial reduction in the cost of nearly everything that the railroads require for their use. Transportation, as well as agriculture, is seriously handicapped, and the purchasing value of its services or product as the result of continuing high wages of labor with high consequent cost—effected to a very considerable extent by governmental policy during the war—has been considerably less than before the war.

The effect of this condition is to put our economic structure out of balance, to the detriment of the entire country. Were it not for the enormous resources of this country our position might easily be serious.

Is it out of place to suggest that engineering groups, through their various organizations, might make themselves felt in influencing a policy that will prevent the depletion of a great basic group to the disadvantage of the whole? We in industry have been compelled in our own interest to exert ourselves actively in this and similar matters. Deplete the earning and purchasing power of transportation or agriculture, and industry and all other groups suffer.

Mr. Rea further states:

The available facts show that the Pennsylvania Railroad has kept pace with the growth of the country and successfully met periods of expansion and depression; it has surmounted the crest of long-continued depressing legislation and regulation and the far-reaching consequences of the World War; it has survived the continuous struggle to prevent confiscation of the railroad investment; it has helped in bringing about a better-informed public and a closer understanding of the necessity for strong railroads with ample net returns; it has always been conservatively managed, has experience and traditions of inestimable value, and is considerably undercapitalized and is one of the effective instruments of national prosperity.

Is not this of material interest to the engineering profession as a group? This is not a matter of politics, it is a matter of sound economics.

As has already been said, one of the problems to be met in the future is the elimination of waste, or of effecting more economic operation and stabilization. Much has been accomplished in this direction of late, but there is vastly more yet to be done, and the need extends into every avenue and detail of our economic structure.

Transportation and industry operating under the necessity of developing not only a living wage but some profit through which alone progress and development may continue, under our highly competitive conditions, needs men to point the way and to develop the method, and as I have already pointed out, the engineer must necessarily play a highly important part. Secretary Hoover is conspicuous in this. Without going into too much detail may I suggest a few possible avenues:

Has steam railway motive power seen its final development as to economy of performance?

Has the deadweight of transport vehicles and train resistance been reduced to an irreducible minimum? It appears that we are yet far from it.

Has the life of rails, ties, wheels and axles, and many other things been brought to a maximum impossible to exceed, and their cost consequently reduced to a minimum? It would seem not.

Here are a few problems for the technician of both transportation and industry:

Has the best labor result and cost yet been developed in industry and transportation, or has the greatest incentive to labor yet been found and applied in a general way, or has the best relation between labor and management been arrived at generally?

Cannot the enormous wastes arising from violent but in a way normal fluctuations in production and employment of labor and capital be seriously grappled with?

If there is one thing more than anything else essential to a sound national life, it is that the people shall have steady and fairly remunerative employment.

Upon investigation just before the war—and similar conditions have prevailed largely since—it was found that the steel industry as a whole, with its enormous investment and large force of employes, was occupied but 70 per cent of the time; that the bituminous coal mining industry was operating at but 50 per cent of its capacity; that the car and locomotive building industry was operating on an average but 65 to 70 per cent of the time. In the car building industry and the industry in which I am engaged, business has fluctuated frequently from an operation of 10 per cent to that of full capacity.

This represents an enormous waste and affects seriously the employment and morale of the worker. Employment and progress in industry and transportation without profits are impossible, and profits are impossible without the continuous elimination of waste.

These are problems for the administrator and technician which, in the light of present day conditions of national and international character, make many other things appear insignificant.

As I have said, the man with scientific training and with practical experience is, in the opinion of many, best equipped to meet these problems.

Mr. Hoover's committee of engineers summarized the result of their investigation as to what was needed in three words: "Specialization," "Standardization," and "Stabilization."

I think it must be clear that if we are to have sound progress balance and stability are essential factors in all of our life and development; and as a principle no one ought to understand this better than the engineer. Here are essential elements not only to higher economic development but to social peace and progress.

What I wish to suggest from this is that we in industry have come to a partial realization at least of the fact that not only must we work out the problems of industry as such, but we must also see the problems in other groups, such as transportation, agriculture, and education, and assist them in their solution.

Now, the substance of all that I have endeavored to present to you is that industry in order to meet the problems of the future is going to need, generally speaking, more men of broader vision than heretofore—in fact, superior in all respects—and that scientific education, revised somewhat to meet the more complex conditions in order to assist in producing such, would be highly desirable; and if the organized engineering groups could lend their influence in support of sound economics, it would be very helpful.

Pennsylvania to Operate Motor Buses

Announcement was recently made by the Pennsylvania Railroad Company that F. J. Scarr, Supervisor of Motor Service of the Pennsylvania Railroad Company, has made application to the Public Service Commission of Pennsylvania for a permit to operate a bus line on behalf of the Pennsylvania Railroad between Washington and Waynesburg, in southwestern Pennsylvania. Transportation service between these two points has for the last forty-eight years been furnished by the Washington and Waynesburg Railroad, a branch line and subsidiary of the Pennsylvania Railroad.

The distance between Washington and Waynesburg by rail is twenty-eight miles and by the highway, twenty-two miles. The present running time by rail is about one hour and forty minutes. Contemplated bus schedules will provide a run of one hour in each direction. Through tickets will be honored on the busses as well as the trains, and through checking of baggage will be similarly handled.

With the increasing use of automobiles, patronage of the passenger service on this branch has declined and it has been found necessary to curtail the service materially. The fast bus line will supplement the train service.

In order to be in a position to handle this and similar situations, steps will shortly be taken to obtain a charter in the State of Pennsylvania for a corporation to be known as the "Pennsylvania General Transit Company." It will be a subsidiary of the Pennsylvania Railroad, which will own all the capital stock.

The announcement further states that it is not the plan of the Pennsylvania Railroad Company either directly or indirectly to enter the general business of transportation by motor bus or motor truck, but to do so only when such auxiliary operation is absolutely necessary to protect existing railroad business or may result in greater economy or public convenience in connection with railroad operations.

Snap Shots—By the Wanderer

The cussedness of inanimate things has passed into a proverb, and yet after all, their apparent cussedness is probably due more to our failure to understand or perceive the application of the laws by which they are governed than to their failure to obey such laws, for failure in this respect is unknown.

Take the matter of gages, for example, we have had so much trouble with them that we recognize the fact that accuracy at every point on an evenly divided scale is out of the question, and that if such scale accuracy is to be required we must resort to a specially graduated one, otherwise we content ourselves with accuracy at each end, as in the case of the ordinary steam gage and let it go at that.

This was brought to my attention the other day by an attempt to calibrate an instrument whose registration was dependent upon the diameter of the impression made upon a strip of cold drawn steel by a hardened steel bull after the manner of the Brinnell hardness test. There was, of course, a steady average increase of diameter as the pressure or load on the bull was increased, but there was very far from being an increase of diameter with every increment of increase of pressure. At times the diameter decreased with these increment increases. And all because of the fact, as an old blacksmith of mine once expressed it, that "it is very easy to make one thing, but it is a devil of a job to make something just like it." So, as the steel maker could not make a bar of steel that was homogeneous throughout its entire length, our results varied accordingly, and yet, after the results had been plotted it was possible to develop a parabolic curve that was nearly coincident with the actual plottings and which served as a reliable average and basis for all subsequent readings and calculations. It is probable that, if the maker could have made his bar absolutely homogeneous throughout its entire length, and we could have applied pressures spaced by exact increments apart, our plotted results would have followed the lines of a parabolic curve, but being as we are, and as "to err is human" we have to put up with approximations however distasteful they may be.

All of which was exemplified at a meeting of the American Society of Mechanical Engineers a number of years ago. Someone presented a paper on chimney draft wherein it was shown that certain chimneys had acted most erratically. But when discussion was turned loose on this subject, it appeared that these same chimneys had been behaving in the most orthodox manner possible and that the author of the paper had merely been ignorant of the laws of governing such structures as formulated by Rankin.

No. Inanimate things are not cussed, but are compelled to follow their individual characteristics whether they were implanted in them by Nature or by man. All of which leads to the conclusion that man and matter are a good deal alike after all.

A good many years ago when we were all enthusiastically riding a bicycle, there came into definite being the movement for good roads. It was a sort of fad at first but giving promises, from the start, of becoming a permanent and lasting utility. It was generally welcomed, and not the least by railroad officials who saw in it a line of feeders that portended an increase of traffic.

With the advent of the automobile the good road movement has become an obsession, and the facilities thus offered for easy transportation has made of them not only feeders to, but rivals of the railroad. As to how much these publicly endowed highways have added to and detracted from railroad revenues it would be difficult to estimate.

But the contribution of a free road to the rapidly developed motor truck has producel a competition in long and short distance hauling that the railroads cannot ignore. If I, an individual, can put one or two or more trucks upon the public highway and compete successfully with a railroad on hauls of from ten to a hundred miles, it follows as a matter of course that the railroads by putting a multitude of trucks in service, with a proper organization, can not only successfully compete with themselves but with me also, to my final extinction and their own probable monopolization of public highway traffic.

And why not? If they can serve the public better and more cheaply than I, why I must yield to their motor trucks just as my grandfather's horse drawn stages had to yield to their steam drawn rail mars.

The railroads are not advertising the fact but they are running motor buses and motor trucks in competition with themselves and outsiders in passenger and freight traffic; adding to congestion and developing conditions that are not altogether what the lovers of country peace and quiet desire.

It will be interesting to see what the politicians and their great mass of unthinking, unreasoning followers will do when they awaken to what they will look upon as an absorption by a soulless corporation of the property of that dear public whom they profess to love so much.

"Here! You gentlemen and ladies have invested millions in public highways and now this grasping corporation comes and steals it from you; wearing them out and beating them into dust. Drive them off, I say. Don't throw away your God-given rights, bought by the sweat of your brow. Throttle them. Exterminate them. Elect me to Congress and I will protect you by seeing that it is done. Selah."

Isn't there a nice little political tidbit? But, how can you drive off the big fellow with his hundreds of trucks and leave me with my one or two unscathed? Where will you draw the line? It will be a puzzle equal to that of the Sophists' determination of the number of grains of wheat required to make a heap. "Does one?" "No." "Two?" "No." "Three—four—five—six—?" "No." Then how many are required? With how many does it begin to be a heap? Why will one less not be a heap?

When will my little accumulation of motor trucks become the emblem of a grasping monopoly? Why if I sell one, will I be no monopoly and if I don't will I fall under the ban? Can I, as an individual, ever become a grasping monopoly? Can the railroad, as a corporation, ever be anything else?

These are nice little bits of casuistry for the politicians to settle, and that they will settle them there can be no doubt, and go raving on with the whole unthinking mob cheering at their heels.

It may seem a far cry from good roads to shop flooring; but, by one of those curious quirks of the mind the latter is suggested by the former. The reason for the leap is that the basis of both is good drainage. Then, add ventilation to drainage and we have a combination making for the best of preservatives of the shop floor. It is not my province or intention within the limits of a paragraph to lay down the rules for the construction of a shop floor, but I can say that it must be kept dry. This is on the assumption that it is of wood, and wood or of some

equally soft material it should be. If you don't believe me just turn your attention to the fatigue and footsore condition resulting to those who work on concrete or stone floors.

But to return to the drainage. The floor should be dry underneath; and, if it be laid upon the ground, that ground beneath should be dry, very dry. While, if it is raised above the surface, then the ground should not only be dry as a result of good drainage, but there should be added a free circulation of air. This will allow your joist to last as long as—well it is said that some of the chestnut timbers in the cool of Westminster Abbey have been there for five hundred years. Perhaps you will need a new shop by that time.

However much we may approve and sympathize with the movement that has "Safety First" for its slogan, we are apt to look upon it with a sort of tolerating amusement. Yet, by and large, it is only by looking at it through the perspective of years that we can realize the immense amount of good that it has accomplished and the great amount of suffering that it has probably prevented.

If we drop back forty years or more, when it was a case of let the workman beware and an accident was the result of an act of God and his own carelessness we can see a mighty change. At that time nothing was protected, and we ran our own risks.

Did you ever have a grindstone burst? We had them all too frequently in those days. It is not quite as bad as a bursting boiler, unless you happened to be in a line with it. Then, I do not know that it made much difference. The flying pieces that have let go from a rapidly running stone hit hard, and the man who happens to be "straddle" at the time, is apt to be hurt. I remember a stone that started out in fragments in Williams' shop years ago, and beside the damage done to the roof and machinery, nearly killed the man using it. Williams didn't mind the financial loss, but it used him all up to think of the man. Then came my first lesson in real safety first. He put in a new stone and barricaded it. There was plenty of chance for the pieces to fly on the off side, but the grinder was as safe as a man would be in a modern turret with an enemy outside popping at him with a 32-calibre revolver. The barricade extended well out on one side of the stone, and ran from the bottom up to the grinding line. It was built of heavy timbers, thoroughly stayed and braced, so that no fragment could possibly get through it. Williams said it was one of those type of accidents that could easily have been prevented by proper precautionary measures and that it would never happen in his shops again. That was for years my sole example of positively safety first.

When I look back at the many danger points that we all knew of in hundreds of shops which could so easily have been done away with by a proper housing, that would seem to have suggested itself to anyone, it seems strange that we were so slow in coming to a proper realization of the need for such precautions. Perhaps we were too busy scrambling for tonnage to give heed to such things. In this we had much to learn from the French and the Germans. I remember being struck by their precautions many years ago and long before we had, apparently, given the subject a thought. I never saw a gear wheel running bare where there was the slightest chance of its catching the clothing of an operator. Everything was housed; gearing, belting, reciprocating rods, and all moving parts that projected beyond the floor line of the machine, or that could in any way threaten the safety of workmen.

But coming down to today, I think that we have caught up. Whether it is propaganda, the re-echoing slogan or just plain common sense and humanity makes no difference; the change from then to now is far greater than most of us realize. Liability insurance has done its share, but even as well as we are now doing there is still enough room for every proprietor and shop superintendent to do a little missionary work in his own establishment.

Motive Power Condition

Locomotives in need of repair on February 15 totaled 10,682 or 16.9 per cent of the number on line, according to reports filed by the carriers with the Car Service Division of the American Railway Association.

This was an increase of 595 locomotives compared with the number in need of repair on February 1 at which time there were 10,087 or 16.0 per cent. It was, however, a decrease of 1,134 locomotives compared with the number in need of repair on the same date last year, at which time there were 11,816 or 18.4 per cent

Of the total number in need of repair, 5,563 or 8.8 per cent were in need of classified repairs on February 15, an increase of 264 compared with February 1 while 5,119 or 8.1 per cent were in need of running repairs, an increase of 331 within the same period.

Class I railroads on February 15 had 4,848 serviceable locomotives in storage, a decrease of 200 compared with the number of such locomotives on February 1.

Notes on Domestic Railroads

Locomotives

The Southern Pacific Company has placed an order for 23 221-ton three-cylinder locomotives with the American Locomotive Company.

The Chicago, Rock Island & Pacific Railway, it is reported, are inquiring for 15 Mountain type, 10 Santa Fe type and 10 Mikado type locomotives.

The Chicago, Indianapolis & Louisville Railway is inquiring for six Mallet type and six Mikado type locomotives.

The Pacific Portland Cement Company has ordered one Mikado type locomotive from the Baldwin Locomotive Works.

The Bwana M-Kubwa Copper Company, of Rhodesia, South Africa, has placed an order for one 2-6-2 locomotive with the American Locomotive Company.

The Texas & Pacific Railway has placed an order for 10 Texas type locomotives with the American Locomotive Company.

The Weirton Steel Company has ordered one 8-wheel switching locomotive from the American Locomotive Company.

The Pennsylvania Railroad is reported to be inquiring for 100 or 200 locomotives.

The Birmingham & Southeastern Railway has ordered one Consolidation locomotive from the American Locomotive Company.

The Canadian Pocific Railway has ordered 24 Pacific type locomotives from the American Locomotive Company, and in addition has ordered 20 Mikado type from the Canadian Locomotive Company.

The Alton & Southern Railroad has ordered one Mikado locomotive from the American Locomotive Company.

The Hainesport Mining Company has ordered one six-wheel switcher from the Baldwin Locomotive Works.

The Modesta & Empire Traction Company has placed an order for one Mogul type locomotive with the American Locomotive Company.

The Florida East Coast Railway has placed an order for 6 eight-wheel switchers with the American Locomotive Company.

The Pennsylvania Railroad has ordered six large electric passenger locomotives and two double cab electric switchers from the Westinghouse Electric & Manufacturing Company.

The Florida East Coast Railway has placed an order for 23 Mountain type locomotives with the American Locomotive Company.

Passenger Cars

The Boston & Maine Railroad has placed an order for 10 gasoline electric cars with the Osgood Bradley Company, two of which are to be 73 ft. long and the others 61 ft. long. Each car will be equipped with 275 horsepower gasoline engine.

The New York Central Railroad has placed a contract for repairs to 10 passenger cars with the American Car & Foundry Company.

The Illinois Central Railroad is inquiring for 5 baggage-club cars, three dining cars and five baggage cars.

The Chicago, Rock Island & Pacific Railway is in the market for five baggage cars.

The Chicago & Eastern Illinois Railway has placed an order for two dining cars with the Pullman Car & Manufacturing Corporation.

The Florida East Coast Railway has ordered 8 baggage cars, 2 diners and 2 postal cars from the Pullman Car & Manufacturing Corporation.

The Delaware, Lackawanna & Western Railroad has ordered two dining cars from the Pullman Car & Manufacturing Corporation.

The Chicago, North Shore & Milwaukee Railroad has ordered 20 passenger cars and 4 diners from the Cincinnati Car Company.

The Chicago, Rock Island & Pacific Railway is inquiring for 5 baggage cars.

The Southern Railway has placed an order for 30 coaches, 15 baggage-express cars, 6 mail-baggage cars and 4 postal cars with the Pullman Car & Manufacturing Corporation.

The Northern Pacific Railway has ordered 10 observation cars from the Pullman Car & Manufacturing Corporation.

The Northern Pacific Railway has placed an order for 3 70 ft. gas electric motor cars, with postal, baggage and passenger compartment, with the Electro Motive Company.

The New York, Westchester & Boston Railroad is inquiring for 10 coaches.

The Atchison, Topeka & Santa Fe Railway has placed an order for 9 diners, 9 club cars, 5 cafe-observation cars and 4 office cars with the Pullman Car & Manufacturing Corporation.

The Richmond, Fredericksburg & Potomac Railroad is inquiring for 4 coaches and 6 express cars.

The Seaboard Air Line Railway is inquiring for 6 passenger baggage cars and 50 steel underframe caboose cars.

The Boston Elevated Railway is inquiring for 100 steel car bodies.

The Central Railroad of New Jersey has placed an order for 5 steel baggage express cars with the American Car & Foundry Company.

The Erie Railroad is inquiring for 23 steel underframe passenger cars.

The Central of Georgia Railroad is inquiring for 6 open coaches and one partition coach.

The New York Central Railroad is inquiring for 10 steel passenger motor car bodies.

The Brooklyn Manhattan Transit Company has placed an order for 201 steel car bodies with the Pressed Steel Car Company.

Freight Cars

The Seaboard Air Line Railway is inquiring for 1,000 to 1,500 40-ton closed box cars, 1,000 to 1,500 40-ton ventilated box cars and 1,000 to 1,500 50-ton gondolas.

The Rodger Ballast Car Company has ordered 2 ballast cars from the American Car & Foundry Company.

The Minneapolis, St. Paul & Sault Ste. Marie Railway is inquiring for 100 general service gondolas.

The General Refractories Company has ordered 2 steel flat cars from the American Car & Foundry Company.

The Chicago & Eastern Illinois Railway is inquiring for 500 70-ton saw tooth steel hopper cars.

The Western Maryland Railway is inquiring for 1,000 40-ton steel underframe box cars and 1,000 40-ton steel center sill box cars.

The American Tar Products Company has increased its inquiry to 100 cars.

The Roxana Petroleum Corporation has placed an order with the American Car & Foundry Company for 400 tank cars.

The St. Louis-San Francisco Railway has ordered 750 box car underframes from the Tennessee Coal, Iron & Railroad Company.

The Northern Refrigerator Line is inquiring for 500 40-ton refrigerator cars in addition to those recently ordered.

The New York Central Railroad has ordered 500 automobile cars from the Merchants Dispatch Transportation Company.

The Illinois Central Railway is inquiring for 220 automobile cars.

The Aluminum Company of America is inquiring for 18 flat cars.

The Birmingham Southern Railway is in the market for 100 70-ton steel gondola cars.

The Atchison, Topeka & Santa Fe Railway is inquiring for 500 hopper cars.

The Southern Railway has placed an order for 500 gandola cars with the Mount Vernon Car Company.

The Great Northern Railway has placed an order for 250 underframes with the Standard Steel Car Company.

The Conley Tank Car Company has placed an order for 100 box cars with the American Car & Foundry Company.

The Pere Marquette Railway is inquiring for 350 40-ton automobile cars.

The Consolidation Coal Company has ordered 900 mine cars from the Bethlehem Steel Company.

The Pacific Fruit Express Company has ordered 5,043 40-ton refrigerator cars, as follows: 1,000 each from the American Car & Foundry Company, the Pacific Car & Foundry Company, the General American Car Company, the Standard Steel Car Company, and 1,043 from the Pullman Car & Manufacturing Company.

The Premium Equipment Company, Houston, Texas, is inquiring for 100 tank cars.

The New England Fuel & Transportation Company has ordered 200 mine cars from the Watt Mine Car Company.

The Swift & Company, Chicago, Ill., has ordered 300 underframes from the Bettendorf Company.

The Seaboard Air Line Railway has placed orders for 1,000 40-ton box cars with the Pressed Steel Car Company and 800 50-ton gondolas with the Pressed Steel Car Company, 800 with the American Car & Foundry Company and 800 with the Standard Steel Car Company.

The Chicago & Eastern Illinois Railway has ordered 500 coal cars from the Mount Vernon Car & Manufacturing Company, and is rebuilding 1,500 hopper cars in their own shops.

The Illinois Central Railroad has placed an order for 2,200 cars as follows: 500 cars to Standard Steel Car Company, 500 to Mount Vernon Car Manufacturing Company, 500 to Pullman Car & Manufacturing Corporation, 500 to Illinois Car & Manufacturing Company and 200 solid bottom gondola cars to the Ryan Car Company.

The Southern Railway is inquiring for 1,000 center sills, 1,000 40-ton box cars, 1,500 50-ton hopper cars and 250 50-ton ballast cars.

The Missouri Pacific Railroad is in the market for 60 50-ton tank cars.

The Litchfield & Madison Railway has placed an order for 200 hopper car bodies with the Ryan Car Company.

The Chicago, Burlington & Quincy Railroad is inquiring for 500 50-ton hopper cars or 500 50-ton composite hopper cars.

The Chicago, Burlington & Quincy Railroad is inquiring for 100 ballast and 500 hopper cars.

The Northwestern Refrigerator Line has placed an order for 500 refrigerator cars with the American Car & Foundry Company.

The Chicago & Northwestern Railway has placed an order for 250 steel underframes with the Ryan Car Company.

The Canadian Pacific Railway has placed an order for 33 75-ton all steel drop bottom side dump ore cars with the Canadian Car & Foundry Company.

The Colorado & Southern Railroad is inquiring for 100 50-ton all steel ballast hopper cars.

The Canadian Pacific Railway is inquiring for 200 75-ton coal cars.

The Northern Pacific Railway is inquiring for 1,000 50-ton automobile cars.

The Commercial Solvents Corporation, Terre Haute, Ind., is inquiring for 35 tank cars.

Buildings and Structures

The Central of Georgia Railway has placed a contract for the construction of a coal chute at Albany, Ga., with the Fairbanks Morse & Company, Chicago, Ill.

The Southern Pacific Company is planning to build an eighteen stall enginehouse, machine shop and tie creosoting plant at Eugene, Ore.

The Missouri Pacific Railroad has placed contract with J. C. Duncan, St. Louis, for the construction of a timber reclamation plant at Sedalia, Mo.

The Cleveland, Cincinnati, Chicago & St. Louis Railroad has placed a contract for the building of an engine terminal at Kankakee, Ill., with the A. J. Glaser Company, Muncie, Ind.

The Montour Railroad has awarded contract for relocation of 4,800 feet of track near Imperial, Pa. The improvement, which necessitates the construction of a 600-foot tunnel and four concrete bridges, will cost $250,000.

The Pennsylvania Railroad has placed a contract for extension to its machine shop at Olean, N. Y., to cost approximately $92,000, with the Lyman S. Peck, Pittsburgh, Pa.

The Norfolk & Western Railway will begin work at once on the rebuilding of its machine shop at East Roanoke, Va. This will cost about $300,000.

The Union Railroad has placed contract with the Roberts & Schaefer Company, of Chicago, for designing and constructing a reinforced concrete automatic electric locomotive coaling and sanding plant and a junior electric "N. & W." type cinder plant for immediate installation at their terminal at Hall, Pa., at an approximate cost of $30,000.

The Central of Georgia Railway has placed a contract for a nine-stall engine house at Albany, Ga., with J. E. Nelson & Sons, Chicago, Ill. Building will be of concrete, brick and wood and will cost approximately $100,000.

The Wabash Railway is making preliminary plans for new rail, track ballasting, yard extensions, etc., on various parts of its system, at a cost of $5,000,000.

The Seabord Air Line Railway plans to erect shops at Indiantown, Fla.

The Gulf, Colorado & Santa Fe Railway plans the construction at Cleburne, Tex., of a boiler house and blacksmith shop, 123 by 155 by 517 feet, also a one-story flue shop, 45 by 288 feet.

The air test room, planing mill and pumping house of the Louisville & Nashville Railroad at Paris, Tenn., were destroyed by fire. The estimated damage is $40,000.

The Chicago & North Western Railway plan the construction of a three-stall enginehouse and mechanical coal chute at Jewell, Iowa.

The Norfolk & Western Railway has awarded a contract for the construction of a 2,000-ton, 6-tract automatic electric roller skip type station and gravity sanding plant at Portsmouth, Ohio, to cost approximately $125,000, with the Roberts & Schaefer Company, Chicago, Ill.

The Cleveland, Cincinnati, Chicago & St. Louis Railway plans to extend its facilities at Kankakee, Ill., including a brick enginehouse and service building, at a cost of $208,900.

The Union Railroad has awarded a contract for the construction of a reinforced concrete, automatic electric coaling and sanding station and electric cinder plant at Hall, Pa., to cost approximately $30,000.

The Boston & Maine Railroad has started the construction of a coke reclamation plant at East Somerville, Mass. The contract for the foundation work has been awarded to the New England Foundation Company, Boston.

The Southern Pacific Company has awarded a contract for the construction of a concrete fuel oil tank at Tracy, Calif. The tank will be 1,300 ft. long and 600 ft. wide and will hold approximately 3,000,000 barrels of oil.

Items of Personal Interest

A. A. Raymond has been appointed superintendent of fuel and locomotive performance of the New York Central Railroad, with headquarters at Utica, N. Y.

E. R. Hanna has been appointed master mechanic of the Central Kansas division of the Missouri Pacific Railroad, with headquarters at Osawatomie, Kans., succeeding **W. P. Kershner**, resigned.

L. E. Crevasse has been appointed master mechanic of the East Florida division of the Seaboard Air Line Railway, with headquarters at West Palm Beach, Fla. **H. C. Quarles** has been appointed master mechanic of the West Florida division, with headquarters at St. Petersburgh, Fla. **G .A. Haslett** has been appointed general road foreman of engines, Central and Southern division, with headquarters at Tampa, Fla.

John McVey, superintendent of motive power and shops of the Consolidated Railroads of Cuba, with headquarters at Camaguey, Cuba, has resigned and will return to the States.

W. O. Thompson has been appointed master mechanic of the Toledo division of Toledo, St. Louis & Western Railroad, with headquarters at Delphos, Ohio. **Edward Elden** has been appointed master mechanic of the St. Louis division, with headquarters at Charleston, Ill.

G. W. Gilleland has been appointed superintendent of motive power, Central and Southern districts of the Seaboard Air Line Railway, with headquarters at Jacksonville, Fla., to succeed **J. J. Hanlin**, who has been appointed master mechanic of the Georgia division, with headquarters at Atlanta, Ga. **W. D. Freeman** has been appointed master mechanic of the North Carolina division, with headquarters at Hamlet, N. C., to succeed **T. J. Raycroft**, who has resigned.

M. M. Kuffner has been appointed blacksmith foreman of the Mobile & Ohio Railroad, with headquarters at Tuscaloosa, Ala., succeeding **W. J. Cronier**, promoted.

Edwin Duder has been appointed superintendent of motive power of the Newfoundland Government Railway, with headquarters at St. John, Newfoundland, to succeed **J. H. Fulmor**, who has resigned.

W. R. Meeder has been appointed superintendent of motive power of the Missouri & North Arkansas Railway, with headquarters at Harrison, Ark. Mr. Meeder was formerly master mechanic.

M. R. Benson has been appointed division master mechanic of the Michigan Central Railroad, with headquarters at St. Thomas, Ont., Canada, succeeding **E. R. Webb.**

C. E. Perkins, president of the Burlington system for twenty years, has resigned and is succeeded by **George B. Harris**, second vice-president.

Thomas E. Cannon, general master mechanic of the Great Northern Railway, with headquarters at Superior, Wis., has been appointed general superintendent of locomotives and equipment of the Pittsburgh & West Virginia Railway, with headquarters at Pittsburgh, Pa.

C. L. Petrikin has been appointed master mechanic of the Southern Railway, with headquarters at Princeton, Ind., succeeding **R. M. Boldridge**, resigned.

W. Stephenson has been elected president of the Missouri & North Arkansas Railway, with headquarters at St. Louis, Mo.

C. W. Lee has been appointed master mechanic of the Seaboard Air Line Railway, with headquarters at Fernandian, Fla., succeeding **C. B. Royal**, resigned.

C. H. Putnam has been appointed superintendent of the shops of the Great Northern Railway, with headquarters at Spokane, Wash., succeeding **J. A. Steele**, resigned.

F. C. Fox, general manager of the Eastern lines of the Atchison, Topeka & Santa Fe Railway, has been grated a leave of absence, and **R. H. Allison** has been appointed acting general manager, with headquarters at Topeka, Kans.

M. Crown has been appointed superintendent of the South Florida division of the Seaboard Air Line Railway and also of the Charlotte Harbor & Northern Railway, with headquarters at Arcadia, Fla.

C. E. Graham, who resigned as senior vice-president of the Chesapeake & Ohio Railway, has also resigned as vice-president of the Hocking Valley Railway and has entered the general railway supply business.

H. J. Plumhof, general superintendent of the Union Pacific Railroad, with headquarters at Kansas City, Mo., has been elected vice-president of the St. Joseph Union Depot Company, succeeding **R. M. Bacheller**, who has been elected president.

Supply Trade Notes

The Central Steel Company, of Massillon, Ohio, has made the following changes: **Fred J. Griffiths**, formerly president, was elected chairman of the board; **C. E. Stuart**, formerly vice-president, was elected president and treasurer; **B. F. Fairless**, formerly vice-president in charge of operations, is now vice-president and general manager; **J. M. Schlendorf**, formerly general sales manager, has become vice-president in charge of sales; **Charles C. Chase, Jr.**, has been appointed secretary. The executive committee has been increased from three to five and includes Messrs. Griffiths, Stuart, Fairless, Schlendorf and William G. Mather, president of the Cleveland-Cliff Iron Company, Cleveland, Ohio.

Edward A. Deed has been elected chairman of the board of the **Niles Bement Pond Company**, New York, succeeding **R. K. LeBlond**, and **J. E. Forrestal**, of **Dillon, Read & Company**, New York, was elected a director.

A. H. Purdom, formerly connected with the railroad department of the **Johns-Manville, Incorporated**, Chicago, Ill., has resigned to take a position in the railway department of the **Wood Conversion Company**, Chicago, Ill., manufacturers of refrigerator and passenger car insulations.

C. E. Graham, formerly senior vice-president of the Chesapeake & Ohio Railway, has now severed his last connection with the property by resigning as vice-president of the Hocking Valley Railway. Mr. Graham has entered the general railway supply business at 51 East Forty-second street, New York City.

The Twentieth Century Gravity Lubricator Company has been incorporated, with headquarters at Baltimore, Md. **W. E. Crist** is president and treasurer; **C. W. MacQueston**, vice-president, and **S. S. Crist**, vice-president and secretary. The company was organized to manufacture oil cup lubricators for journal boxes.

The Chicago Steel Car Company, Harvey, Ill., has changed its name to the **Gibson Car & Manufacturing Company. R. A. Pascoe**, secretary of the **Whiting Corporation**, has also been appointed secretary-treasurer of the Gibson Car & Manufac-

turing Company, and **T. S. Hammond**, president of the Whiting Corporation, has been appointed vice-president of the Gibson Car & Manufacturing Company.

The Superheater Company of New York and Chicago recently elected **M. Schiller** vice-president in charge of accounts and purchases, and **W. F. Jetter** treasurer and assistant secretary. **Bard Browne** was appointed assistant to vice-president in charge of sales and service, **T. F. Morris**, assistant secretary and assistant treasurer.

All of these men have been long associated with the Superheater Company. Mr. Schiller joined the company in 1910 when it was organized as the Locomotive Superheater Company, and has served in various administrative and executive capacities. Mr. Browne came with the company in 1914 and has been actively identified in the application of locomotive superheaters and feedwater heating devices, serving in various engineering, sales and service capacities.

The Superheater Company are designing engineers and manufacturers of Elesco steam superheaters for locomotive, marine and stationary boilers, feedwater heaters and exhaust steam injectors for locomotives, pipe voils, etc. The company is composed of engineers who have had long experience in the design and perfection of equipment for locomotive, and marine and stationary power plant services. They are the world's largest manufacturers of steam superheaters and have affiliations in Canada, England, France and Germany.

W. B. DeForest, manager of the Kansas City distributing house of the **Graybar Electric Company**, New York, has been transferred and is now sales manager of the company, with headquarters at New York, **J. F. Davis**, formerly sales manager at New York, has been transferred to the general staff department, at 100 East 42nd street, New York. **F. G. Caldwell** has been appointed manager of the Houston, Texas, distributing house. He will report to **R. W. Van Valkenburgh**, manager of the Graybar Dallas house. **R. F. Copes** has been appointed sales manager of the Norfolk, Va., distributing house, reporting to **G. T. Marchmont**, manager of the Richmond dsitributing house.

The Morton Manufacturing Company, Chicago, will construct a two-story factory, 85 ft. by 220 ft., to cost approximately $95,000.

The Oliver Electric & Manufacturing Company has removed its factory and general office from St. Louis, Mo., to 1334 North Kostner avenue, Chicago, Ill.

Godwin Shenton, formerly assistant to the president and manager of the **Coplan Steel Corporation**, Ogdensburg, N. Y., is now associated with the **Q. & C. Company** in the mechanical staff and will specialize and co-operate with the **Ohio Steel Foundry Company**, of Springfield and Lima, Ohio, in the manufacture and sale of locomotive grate bars made of special heat enduring steel. Mr. Shenton's headquarters will be at 90 West street, New York City.

E. T. McCleary, assistant vice-president in charge of operation of the **Youngstown Sheet & Tube Company**, Youngstown, Ohio, has been promoted to vice-president in charge of operations.

T. Holland Nelson has become associated in a consulting capacity with the **Ludlum Steel Company**, Watervliet, N. Y. Mr. Nelson is also vice-president of the **William T. Bate & Sons Company**, Conshohocken, Pa. He has been intimately connected with the development of rustless steel both in this country and in England.

R. M. Thomas and **Donald Charlton** have been appointed technical representatives of **Reading Iron Company**, Reading, Pa. The Technical Department which they head is a newly created service division in the Sales Department. All their time will be given over to railroad work and they will be required to give technical and practical counsel to any railroad which has pipe, engine-bolt, stay-bolt and boiler tube problems. R. M. Thomas, for the past four years associated with the Chicago office of Reading Iron Company, received his technical training at Cornell University and Carnegie Institute of Technology. He is a member of American Institute of Mining and Metallurgical Engineers and Western Society of Engineers. Mr. Thomas will represent Reading Iron Company in offices of various railroad systems of the West. His headquarters will be 449 Conway Building, Chicago, Ill. Donald Charlton has been for the past six years in the manufacturing division of Reading Iron Company, the last two and one-half years of which he served in the capacity of assistant engineer of tests. His duties during this period required an intimate knowledge of railroad work and furnished an excellent opportunity to become acquainted with numerous railroad inspectors and technical experts of several systems. Mr. Charlton will call on Eastern railroads and his headquarters will be the general office of Reading Iron Company, Reading, Pa.

C. L. Sidle, salesman in the industrial water softener department of the **Wayne Tank & Pump Company**, Fort Wayne, Ind., has been promoted to sales manager of that division, to succeed **E. L. Horiskey**, resigned.

The Ohio Injector Company, Wadsworth, Ohio, has established a branch office at 30 National Building, Cleveland, Ohio, and has appointed **F. L. Dalzell** district sales manager.

A. G. Smith has been appointed superintendent of the steel works department of the **Forged Steel Wheel Company**, Butler, Pa., subsidiary of the Columbia Steel Company, Elyria, Ohio. Mr. Smith formerly had been superintendent of the open-hearth department of the **Trumbull Steel Company**, Warren, Ohio.

J. F. Fierke, president of the Illinois Iron & Bolt Company, Carpentersville, Ill., has also been elected president of the **Chicago Railway Signal & Supply Company**, Chicago, succeeding **E. W. Vogel**, who has resigned to engage in other business. **Charles O. Poor**, president of the **P. & M. Company, Ltd.**, Montreal, Quebec, and formerly president of the **General Railway Signal Company of Canada, Ltd.**, has been appointed vice-president and manager of the Chicago Railway Signal & Supply Company, with headquarters in Chicago.

George T. Aitken has been made manager of machine tool motor sales in the electrical division of **Fairbanks Morse & Co.**, with headquarters at Indianapolis. Mr. Aitken was formerly sales manager of the **Vonnegut Machinery Company** of Indianapolis.

W. H. Warner, general superintendent of Trumbell Steel Company, Youngstown, Ohio, has resigned, and **C. H. Elliott**, vice-president, is directing operations.

The Commonwealth Steel Company has moved its headquarters from St. Louis, Mo., to Granite City, Ill., where its main plant is located.

J. M. Harris, Elza Isaacs and **H. O. Carlson** have organized the **American Boiler Washing Device Company**, office located at West Frankfort, Ill.

Robert W. Gillispie has been made assistant manager of structural and plate sales of the **Bethlehem Steel Corporation**, Bethlehem, Pa. **C. M. Daniels** is made plate sales agent, office at that point. **Lee Hillard** goes to Chicago as structural and plate sales agent.

J. W. Hewitt Rubber Company of Buffalo has merged the **Gutta Percha & Rubber Manufacturing Company** of New York. Branch agencies will be maintained in New York, Boston, Philadelphia, Baltimore, Atlanta, Chicago, Pittsburgh, Denver, Los Angeles, Seattle and San Francisco.

Obituary

W. J. Tollerton, general superintendent of motive power of the Chicago, Rock Island & Pacific Railway, Chicago, died at his home March 3, following a week's illness of influenza. Mr. Tollerton was born in St. Paul, Minn., January 2, 1870, and entered railway service as a machinist apprentice for the Northern Pacific Railway. He transferred to the Chicago, St. Paul, Minneapolis & Omaha Railway as fireman, and later to the Union Pacific Railroad as general foreman and master mechanic at Pocatello. He served as master mechanic on the Idaho, Utah and Montana divisions of the Oregon Short Line Railroad from 1896 to 1906, when he transferred to the Chicago, Rock Island & Pacific Railway at Topeka, as superintendent of motive power in charge of lines west of the Mississippi River. He was promoted to assistant superintendent of motive power at Chicago in April, 1907, mechanical superintendent, May, 1912, and general superintendent of motive power at Chicago, January 1, 1913, which position he was holding at the time of his death.

Daniel M. Brady, president and treasurer of the **Brady Brass Company**, Jersey City, N. J., died on February 23. Mr. Brady was born in New York City in 1854 and entered the service of the New York Central as an office boy, in 1871, and served as a clerk to J. M. Toucey, superintendent of the Hudson River division, and general manager of the Grand Central Terminal. He later was promoted and served in the office of the superintendent of car repairs under Leander Garey. He afterwards served under William Buchanan and then became connected with a car wheel company in Rochester. He subsequently was identified with the Paige Paper Car Wheel Company and then started a brass company under the name of the Brady Metal Company, with office on lower Broadway, New York. About 1888 he organized the Brady Brass Company, of which he was president and treasurer at the time of his death.

New Publications

American Society for Testing Materials. Proceedings of the Twenty-Eighth Annual Meeting. Published by the Society, Philadelphia, Pa. Two volumes; 962 and 454 pages; 6 in. by 9 in. Paper.

Of the two volumes the first or Part I is the larger and contains the committee reports, the new and revised tentative standards and a list of standards and tentative standards. Part II contains the technical papers presented at the 1925 meeting at Atlantic City, New Jersey, and the discussions thereon.

As is well-known the society has taken up, discussed and developed standards and specifications for such a wide range of materials that to the lay mind they seem to cover about every known product. As it stands the society now has 256 standards and 193 tentative standards or about sixteen for each year of its existence, a fairly prolific record.

With sixty committee and sub-committee reports and the presentation of 83 suggested revisions of tentative standards and 33 similar suggestions relatively to the already adopted standards, it is evident that a review of all that the volume contains is impossible within available limits.

Reference may be especially made to the very interesting and important report on X-Ray metallography, an extract from which is reproduced in another column, where the achievements and possibilities of this method of inspection are set forth.

There is a progress report on the preparation of iron and steel for painting, that is an apparent corroboration of what we have been taught for years as to the value and efficiency of sand blasting. As all knowledge has a more or less remote bearing on all arts so it is probable that every report in this large volume holds something of interest to every railroad man.

The volume of technical papers contains twenty-six papers on a wide variety of subjects of which eight are devoted to metals and the balance to cement, concrete, gypsum, brick, bituminous materials, paint and textiles, with none of them having a direct bearing upon the locomotive or the car.

A very interesting diagram is published in connection with the annual report of the executive committee showing the growth of the society since its formation in 1898. There was a rather rapid growth for the first two years, with a much slower one for the next two; then, since 1902, the growth has been remarkably steady and uniform, averaging more than 150 new members a year until at the time of issuing the report, there was a membership of 3716. The number in attendance at the annual meetings also shows a steady general increase, though there are some fluctuations, with a notable drop in 1912, until in 1925 there were nearly 800 in attendance. The diagram also shows the growth in the number of pages contained in the publications of the society annually. These have been subject to wide fluctuations but with a general increase in number, rising to about 3900 in 1924, in which year there was an increase of more than 1500 pages above that of the year before.

Switching Equipment for Alternating Current Power Stations. The Westinghouse Electric and Manufacturing company has just issued a 112-page publication describing the proper switching equipment for alternating current power stations. This special publication, 1541-C deals with the general fundamentals that should be borne in mind when laying out a switch board, and describes in detail the various types of switching equipment. It is profusely illustrated with diagrams and half-tone illustrations.

The choice of switching equipment arrangement is well described, and with it are included switching devices and classes of stations of both the single bus and double bus systems.

Safety enclosed switchboards are the subject of a very interesting section, and the direct control switchboard for 2500 volts or less with oil circuit breakers and bus bars supported from the back, are explained in another section.

The electrically operated switchboard material is particularly interesting and includes descriptions of panel boards, control desks, synchronizing devices and other data, including supervisory control equipment.

Several full page spreads of illustrations of various types of oil circuit breakers and switchboards, including installation views, complete the publication.

This publication may be had from any of the district offices or the Publicity Department of the Westinghouse Company, at East Pittsburgh, Pa.

"Electric Night by Radio," issued by the General Electric Company of Schenectady, N. Y., as publication GEA-324, contains the addresses which were broadcast on "Electric Night," October 21st, from eighteen broadcasting stations, covering the United States. This national celebration was sponsored by General Electric to commemorate the 46th anniversary of the Incandescent Lamp and to pay tribute to Thomas A. Edison.

History, progress, rural electrification, public relations, and many other subjects relating to the electrical industry are discussed. Among the thirty-two speakers were two members of the Cabinet, Herbert Hoover, Secretary of Commerce, and William M. Jardine, Secretary of Agriculture, in addition to official of banks, electrical associations, central station companies and manufacturers.

"Some Developments in the Electrical Industry During 1925," by John Liston, has been issued as a 62-page publication (GEA-355) by the General Electric Company, Schenectady, N. Y. The review covers each phase of electrical application and its outstanding developments during the past year. It is divided into numerous sections, contains 103 illustrations and an index.

Railway and Locomotive Engineering

A Practical Journal of Motive Power, Rolling Stock and Appliances

Vol. XXXIX 136 Liberty Street, New York. April. 1926 No. 4

Large Gas-Electric Passenger Car for the Boston & Maine Railroad

Some Details of Its Construction and Operation

An extra large gas-electric car of modern design and capable of seating 92 persons has just been delivered to the Boston & Maine Railroad. The car is to be used without a trailer as its capacity is sufficient to meet the service conditions on the branch line over which the car will operate, and where it is expected that the savings in operating costs will greatly reduce the expense of operation.

It is estimated that all of the principal operating costs of this single car unit will be lower than those for the steam train it is replacing. It is expected that the fuel costs will be less because of the decrease in the total train weight per passenger seat, as well as because of the reduction in the number of vehicles. The same holds true of the labor costs since there will be no need of a second man in the engine room corresponding to the fireman on the steam train. It is also thought that less frequent overhauling will be required, which will reduce maintenance expenses. Then there is the feature of a practically continuous service in long daily runs that cannot be accomplished with a steam locomotive. When it is the only power used upon a branch line, it will be possible to discontinue the coaling and water facilities.

The 73-Ft. Brill-Westinghouse Gas-Electric Car Built for the Boston & Maine Railroad

The electric equipment was designed and it and the engine built by the Westinghouse Electric & Manufacturing Co. The engine was designed by The J. G. Brill Co. of Philadelphia, Penna., as was the car body and running gear, by which company the whole was assembled.

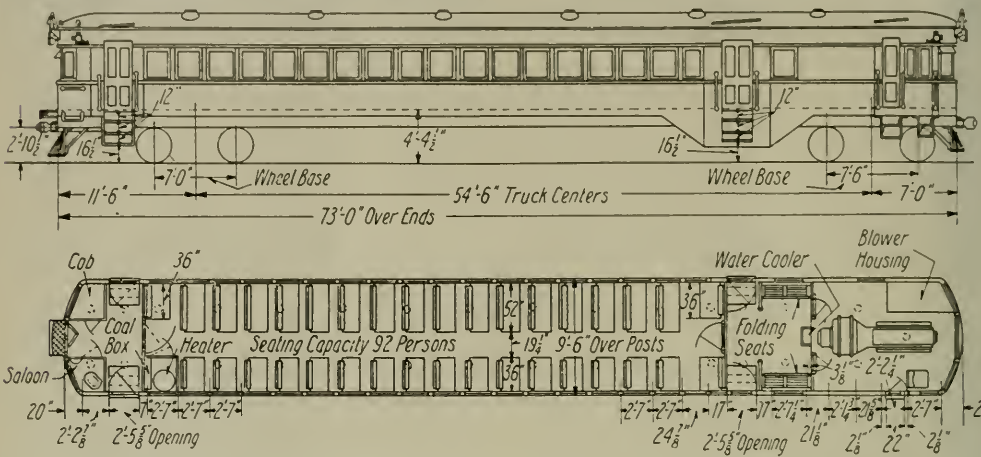
The car body is of light-weight steel with straight sides and arched type roof. The underframe consists of two 12-inch channels to which are riveted the cross members supporting the car body. The posts are of spring brass. The overall length over the end sills is 73 ft. The weight without load is 110,000 lbs., and the estimated full seated load 14,000 lbs.

The main passenger compartment is 46 ft. 6 in. long and is fitted with 35 seats for 84 passengers. The aisle is located slightly off the center line of the car as the seats on one side are capable of holding three persons and on the other only two. This type of seating arrange-

ment gives an unusual low ratio of floor area to seated passenger and, hence, is a very economical type of design. The entrance to this compartment is through end center entrance swing doors that open at the rear end onto the vestibule and at the front end into a small baggage or storage compartment.

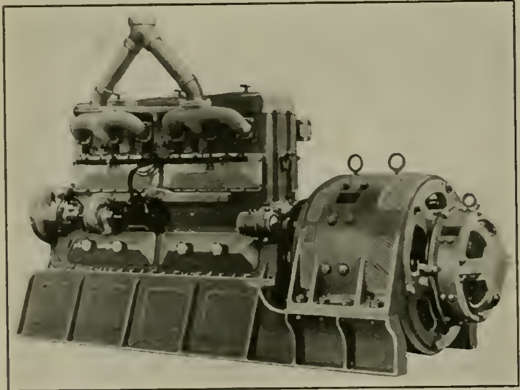
The baggage compartment is fitted with two folding control cab is located at the rear of the car on the right hand side. This second control cab is entirely enclosed. The car ends are rounded and fitted with three clear view glass windows at the front end and two windows with a center folding door at the rear end.

All of the controls and switches can be reached from the operator's seat. There are three lever handles and a



Side Elevation and Floor Plan of Brill-Westinghouse Gas-Electric Car for the Boston & Maine Ry.

seats and can be used as a smoking compartment. Four side entrance doors are provided for the passengers and one for the operator. The rear vestibule is fitted with two doors and the storage room with two. The operator's door is located at the rear of his seat in the engine room. A saloon is located on the rear vestibule. The



The Brill-Westinghouse Engine Generator Unit for the 73 Ft. Boston & Maine Car

car is heated by a hot water circulating system, the coal heater being located at the rear of the main passenger compartment.

The engine generator unit is mounted at the forward end in a 11 ft. 6 in. compartment which also houses all of the engine auxiliary apparatus and the control equipment. The operator's seat and controls are located at the forward right hand side of this compartment. The control is arranged for double end operation. The other

number of switches. There is one small lever with a notched quadrant at the front end of the engine bed for advancing or retarding the ignition. This lever does not appear on the illustration of the engine as it is on the right hand side; the illustration being on the left. Then there is the handle of the engineer's valve of the air brake, and finally the operating lever, which also has a notched quadrant attached. This lever connects to the valves on the carbureters. This and the brake lever form the principal control that has to be operated by the engineer. Forward movement of the engine throttle lever increases the fuel supply to the cylinders and, hence, increases the engine speed. This lever is also interlocked with the electrical control switches in such a way that the motors are connected to the generator and the generator excited before the amount of fuel fed to the cylinders is increased enough to cause the engine to get above idling speed. In this way the electrical equipment is completely disconnected when the engine idles and only one lever is required to raise the engine speed and reconnect the generator and motors for operation.

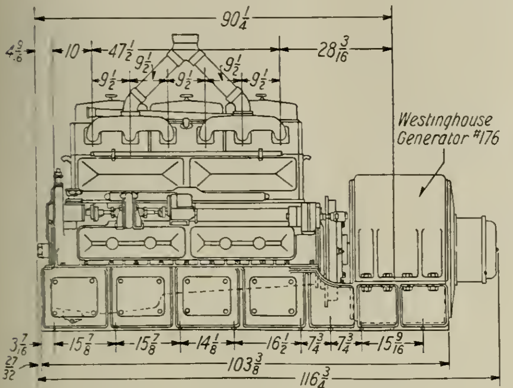
The engine of course operates in one direction at all times, and the reversal of the motion of the motors is accomplished by a small two-position plug switch; the plug being inserted in one hole or the other according to whether a forward or backward motion is desired. When the plug is entirely removed the motors are dead.

This reverser and electro-pneumatically controlled switches care for all the main generator and motor circuits. No main circuits are broken near the operator's position. This reduces hazard and safeguards the engineer. The electro-pneumatic switches are operated by electrical interlocks on the engine throttle lever.

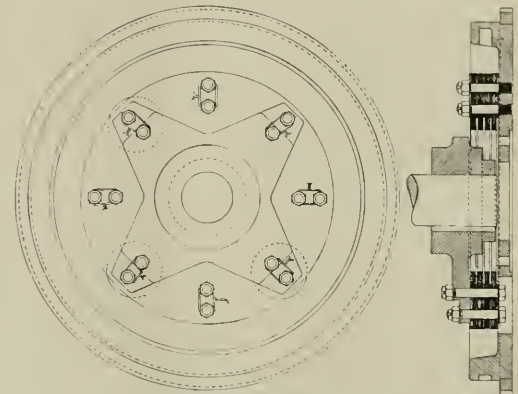
Attached to the window post and side of the car at the right of the engineer are a number of switches that serve to put the motors into series or parallel action, control the headlight, and a number of other minor purposes. There is also a valve for controlling the operation of the pneumatic bell ringer.

A 32-volt battery supplies energy for car lighting and for the control circuits when the power plant is shut down and also furnishes the excitation for a small 50-volt 2.5 KW exciter mounted on an extension of the generator shaft. This exciter supplies power to a shunt field winding on the main generator and for charging the battery and supplying the lighting and control circuits.

The engine is a 250-horsepower, six-cylinder gasoline



Side Elevation of Brill-Westinghouse Engine Generator for 73 Ft. Car



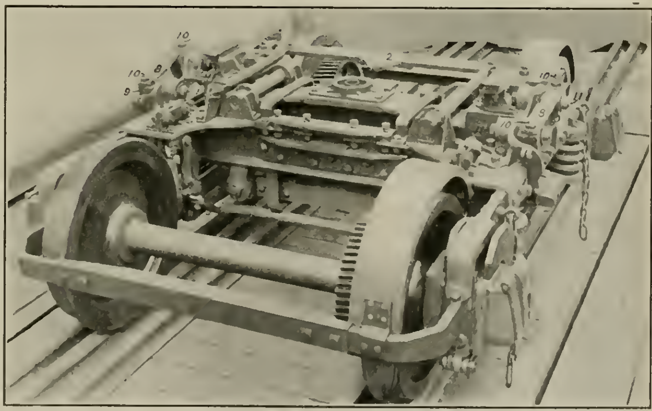
Thermoid Fibre Coupling for Engine and Generator of Boston & Maine Gas-Electric Car

engine driving a 160-kilowatt generator as shown in the illustration. The power is supplied to two 140-horsepower, 600-volt traction motors mounted on the forward truck.

The engine is substantially built to withstand continuous full speed operation incident to service in a gas-electric car. Its normal speed is 1100 revolutions per minute, and this speed is maintained except when the car is coasting or when slow-speed operation is desired. The cylinders are $7\frac{1}{4}$ in. bore by 8 in. stroke, cylinders cast en bloc, heads in pairs, and are equipped with two sets of overhead valves and two spark plugs per cylinder to insure reliable operation. The ignition system is in duplicate as in addition to the two spark plugs per cylinder two magnetos are mounted on the engine and are driven independently.

The generator is connected to the rear of the engine by means of a flexible coupling consisting of four fabric discs. The combined unit is mounted on a common bedplate longitudinally in the forward end of the car and rests on the car channels. The generator is specially designed for this car and motors are standard 600-volt railway equipment. Their characteristics are such that the full horsepower of the engine is absorbed over a wide operating speed range of the car without any manipulation of control levers by the operator. The car speed is controlled by the engine speed. The flexible fabric universal joint used between the gasoline motor and the generator of this passenger car consists of four Thermoid Hardy Universal Joint Discs which are bolted directly to the flywheel of the gasoline motor. A spider fastened to the end of the generator shaft is also bolted to the discs in such a manner that the one flywheel bolt alternates between two of the spider arm bolts. The main function of the disc joint is to allow for any slight misalignment of the engine and generator or any angularity between the shafts of the two. A secondary purpose is the cushioning of the impulse load on the engine crank shaft and a dampening of the vibrations set up in the shaft. This all contributes to the smooth, quiet operation of the unit since the vibrations are not carried back to metal parts which might create a noise.

The fabric discs used are the Thermoid Hardy type with the fanwise construction of plies as shown in the illustration which gives a uniform pull between all pairs of bolt holes. The fabric used is a heavy 20 oz. long fibre duck thoroughly impregnated with a rubber compound which gives a maximum adhesion between the



Brill M. C. B. Motor Truck for the Boston & Maine Gas-Electric Car

separate plies. The plies of each disc are laid up as mentioned before with the threads running in different directions until sufficient thickness is obtained. The discs are then punched out and placed in the moulds and vulcanized under pressure to give the finished product. The finished discs are made within 1/64 in. tolerance in thickness, 1/32 in. tolerance on the inside and outside diameters and with a plus or minus of .010 in. tolerance on the bolt hole spacings. The tensile strength of the

material in the discs runs well over 3000 lbs. per square inch.

The car is mounted on standard high-speed M. C. B. Brill trucks. The electric traction motors are mounted on the forward truck which has a wheel base of 7 ft. 6 in. The wheel base of the trailing truck is 7 feet. The wheel diameter is 33 inches. The truck center distance is 54 ft. 6 in.

This truck has been in extensive use for a number of years on electric railways, but is a comparative novelty on steam railway service. As rather exceptional results are obtained with it because of some of the details of its construction, those details are worthy of careful consideration.

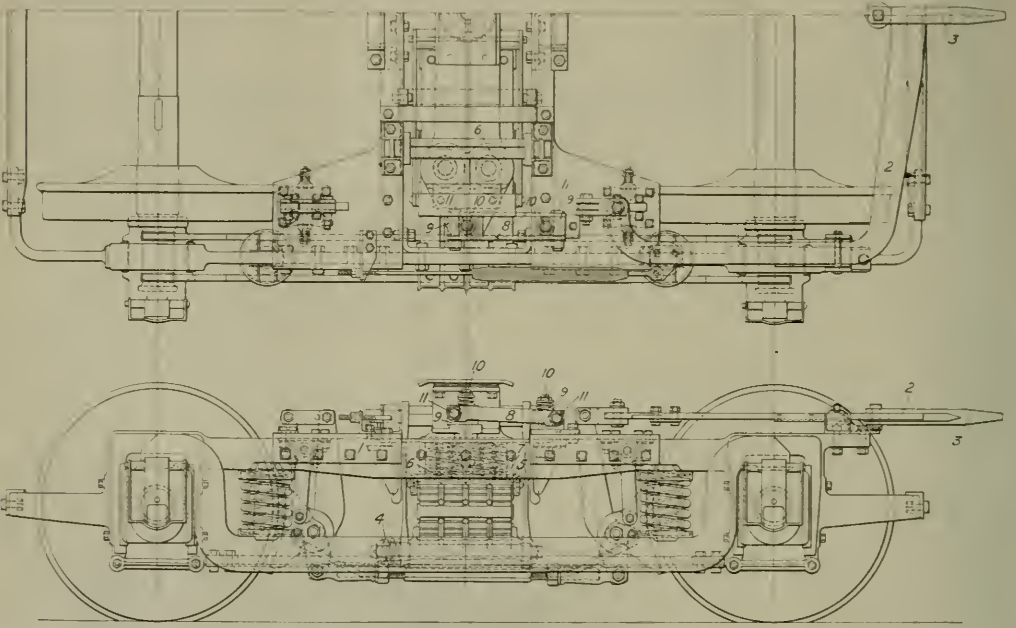
Its general appearance is that of the old standard type of four-wheel passenger car truck but is of all metal construction. The side frames are forgings, with the end pieces, transoms and equalizers are all modeled along conventional lines. The connection between the side frame is strengthened by a stiff gusset that laps down over the outside of the side frame at 1 as shown in both the side elevation and photographic reproduction.

The brakes are inside-hung, with a system of levers adapted to leave the space between the axles and the transoms open for occupation by the motors. This is accomplished by the use of a yoke bar, 2, acted upon at the center by the pull rod, 3, of the car brake rigging, and pulling at its ends upon the upper end of the live brake levers, of which there is one on each side. This makes a mere separator of the brake beam to hold the shoes and levers in place, as no other load is put upon it.

The side frame rests upon the equalizers in the usual way by means of the equalizer springs.

The spring plank is carried by hangers suspended from the transoms, with the bottom ends spread to assist in the return of the plank and its superincumbent load to the central position. The spring plank pin is held by a nut and washer with a spring 4 beneath. The purpose of this spring, as originally applied, was to hold the pin steady and prevent it from rattling, the earliest applications having been to brake hangers. In this case another function has been added. The spring has been made much heavier than would have been required to simply prevent a rattling of the bolt or pin, and has been given a strength and tension so as to produce a considerable frictional resistance between the pin and hanger. This opposes a force to resist the swinging of the hanger and the spring plank. This retards the swinging of the hanger and the spring plank and so softens the motion of the latter to contribute to the ease of motion of the body of the car.

The elliptic springs rest directly upon the spring plank, but do not carry the bolster direct. At the top of the elliptic springs there is a double-seated spring seat 5. This spring seat rests on top of the elliptics and carries



Side Elevation and Plan of the Brill M. C. B. Truck Used with the Boston & Maine Gas-Electric Car

a nest of light helical springs, 6, in its upper seat. It is upon these springs that the bolster rests. They are so encased that, after a comparatively light load, the edge of the lip of the casing at 7 rests on the top of the spring seat beneath, and any further increase of load has no effect on these springs. They are made strong enough to carry the weight of the empty body, but as a load is put on they compress and go out of action. Any additional load is taken care of by the elliptics and the helical equalizing springs.

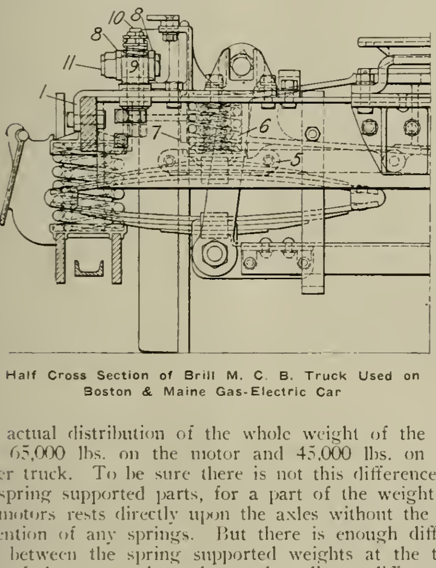
With this arrangement an easy riding car is obtained when both light and loaded.

One of the annoyances and obstacles to easy riding of cars is the frictional contact of the bolster against the inner side of the transoms. This contact causes sticking, jars and tilting. On this truck the bolster moves freely up and down between the two transoms without being in contact with either. It is held in a central position by two rocking arms 8; one at either end of the bolster. One end of the arm is pivotted on the transom and the other on the bolster. At each end it is held by

a universal joint. Blocks, 9, 9, are held to the transom and bolster respectively by the spring-washered bolts, 10, 10, respectively. The blocks are, therefore, free to turn in a horizontal plane about the vertical bolts. The arms 8 are pivoted on these blocks by the bolts 11, which gives them freedom to oscillate in a vertical plane. The vertical and latteral movements of the bolster are thus unhampered; while it is, at the same time, held midway between the two transoms except for the slight differences caused by the variation in the angularities of the arms 8.

If the riding of this particular car may be taken as a criterion, this construction seems to have accomplished two very desirable results.

It is well known that the ordinary dining car is a notoriously bad riding vehicle. The roughness is at once noticeable on stepping into such a car from a parlor or sleeping car. This characteristic has been attributed to the fact that the weights at the two ends of the car are very unequal, because of the heavy range and kitchen equipment, that is located at one end. But, in this car, there is a far greater variation in the weights on the trucks than obtains in any dining car, for there is the heavy engine, generator and other auxiliary equipment.



Half Cross Section of Brill M. C. B. Truck Used on Boston & Maine Gas-Electric Car

The actual distribution of the whole weight of the car puts 65,000 lbs. on the motor and 45,000 lbs. on the trailer truck. To be sure there is not this difference in the spring supported parts, for a part of the weight of the motors rests directly upon the axles without the intervention of any springs. But there is enough difference between the spring supported weights at the two ends of the car to show that such ordinary differences as do occur are not insuperable obstacles in the way of securing an easy riding car.

Another point along the same line is the matter of nosing or zigzag movement, when running on a straight track.

It is well known that cars mounted on four-wheeled trucks, when running free and sometimes even when coupled in trains exhibit this tendency to nose to a marked and, often, to a dangerous degree. This car, on the other hand, runs smoothly and evenly on a straight track, at 40 miles per hour and is reported to act equally as satisfactory at speeds up to 60 miles per hour.

It will be noticed, in the reproduction of the photograph of the truck, wheel guards are placed over the wheels on the right hand side. This is to protect the fan openings in the floor of the car directly above from any mud or dirt that may be thrown off by the wheels.

The 250-horsepower engine makes possible high-speed operation of this car over a rolling profile and gives it excellent performance characteristics. The following schedule speeds are possible on the indicated grades for the given length of runs. A stop time of 30 seconds has been assumed.

	Grade in Per Cent					
Length of Run Miles	0	0.1	0.2	0.5	1.0	1.5
3	32.7	32	31.2	29.7	27	24
4	35.4	34.7	34.2	32.2	29.7	25.6
6	39	38.3	37.4	34.7	30.6	26.6
8	41.2	40.2	39.6	36.2	31.4	27.2
10	42.2	41.6	40.4	37	32.2	27.4

An idea of the power needed for the propulsion of a car of this type is obtained from the fact that with electric transmission, and against only a slight headwind, 250-horsepower are needed at the engine at a car speed of 50 miles per hour. The power needed goes up rapidly with increased headwind resistance. This increase in power needed is very noticeable in both the running speeds possible and the gasoline consumption. Headwind resistance will vary the gasoline consumption on a 100 mile run as much as 30 per cent.

The accompanying curves give in detail the maximum schedule speed possible with this car on various grades with varying length of runs. As shown, the schedule speeds possible are affected very little by grades below 0.3 per cent. This is a very favorable condition as it makes possible a daily average uniform performance, under varying weather conditions, over a run with a rolling profile.

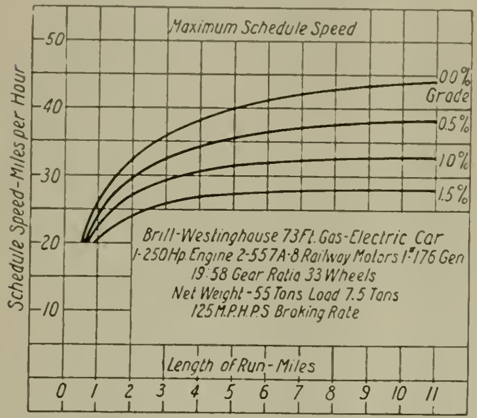
The operation of this car is particularly economical as the unit has a very low ratio of weight to seating capacity and a low ratio of weight to the rated engine horsepower. The car weighs only 1200 pounds per passenger seat and only 440 pounds per engine horsepower. These low ratios, in addition to causing low operating expense, give the car excellent speed characteristics that are very desirable. The flexibility of the control and the electric transmission permits the full utilization of the available power over a wide car speed range.

In comparison with other gas-electric cars this unit has additional advantages that make its operation on branch lines very satisfactory. The economies of gas-electric car operation are dependent upon several factors. Among these are low weight of equipment and the passenger load ratio. The most desirable and economical field for the gas-electric unit is one where the load capacity required is reasonably small, but constant and wher. the engine power plant can be so designed that the full power is used continuously. Until recently only sixty-foot cars, and smaller ones of this type have been coustructed to meet various service conditions. Such units as these have been built with power plant capacity for either single car or trailer operation. The smaller car when suitable for trailer operation is a very flexible unit, but not the most economical unless the trailer operation is continuous. Where service conditions are such that the loads are small and practically constant, and where the capacity of the 73-foot car is adequate for the service, there is no doubt that it will prove lower than the single motor car unit with a trailer or the steam train.

The present unit is one of the three purchased by the Boston & Maine Railroad from the Brill and Westinghouse Companies, the other two units being standard 60 ft. cars. Five of the 73 ft. cars have recently been placed on order with the J. G. Brill Company by the New York, New Haven & Hartford Railroad.

When this car was on its way to delivery to the Boston & Maine Railroad, a demonstration run was made on the

Pennsylvania Railroad from Philadelphia to Trenton, New Jersey, a distance of about 32 miles. The highest speed attained on the run was a little more than 42 miles an hour, and shortly thereafter a slow order was issued limiting the speed to 30 miles an hour so that there was no opportunity to demonstrate what the car could do while



Performance Curve for Brill-Westinghouse, Boston & Maine 73 Ft. Gas-Electric Car

running at that speed, of a little more than 42 miles an hour, the engine was turning at the rate of 900 revolutions per minute and the generator was delivering 250 amperes of current.

It is estimated that if the engine were to deliver 200 horsepower the rate of gasoline consumption would be at about .90 lb. per horsepower per hour for the power being so delivered. The gasoline tank beneath the frame has a capacity of 150 gallons or approximately 975 lb. So that the car could run something more than 200 miles on a single tank of gasoline.

Immediately upon the receipt of the car it was placed in service between Springfield and Northampton, Mass. The distance between these two points is about 17 miles, and the district served includes Springfield with a population of about 142,000, to which there are two large tributary towns, Holyoke of about 60,000 inhabitants and Northampton with about 22,000. In addition to the normal travel between these places there are three colleges whose students are constantly going to and from Springfield. These are Smith College at Northampton; Mount Holyoke College at South Hadley and Amherst at Amherst. So that a heavy local traffic has to be provided for. Within three days of the placing of the car on the run it was carrying loads of more than one hundred passengers. As the car has developed a capacity to haul a trailer it is probably capable of handling the comparatively heavy traffic that will develop in this region.

Cost of Operating Gas and Oil-Electric Locomotives

Mr. J. C. Thirwall of the General Electric Company has issued a statement regarding the costs of operating gas and oil electric locomotives and cars in railway service. According to this statement the gas-electric cars seating from 54 to 64 passengers, with coach, smoking and baggage compartments, are equipped with large capacity engines and generators, and use standard trolley car motors and controllers. One type that has been widely purchased weighs about 38 tons and uses a 6 cylinder engine that develops 175 h.p. at 1,000 r.p.m. These units, operating in infrequent stop service, will run about 3 miles per gallon or use 65 to 75 gallons in running 200 miles daily. About 65 such cars have been put into service during the past two years because their entire operating expense is only a small fraction of that of a steam train on lines of light traffic.

A further and more recent development, along similar lines, is the oil-electric locomotive for switching service on steam roads. These are built in several sizes from 60 tons to 125 tons, the mechanical structure being designed and built by the American Locomotive Company, the oil engines furnished by the Ingersoll Rand Company and the electric equipment by the General Electric Company. The engines range from 300 h.p. to 750 h.p. and the electric generators from 200 k.w. to 500 k.w. capacity. Such units can produce power for approximately .65 lb. of oil per kw-hr. and even in intermittent service, with widely varying loads and power factor, their fuel economy compares favorably with that of the large central steam stations.

As compared to a steam locomotive, in switching service, with its huge standby and idling losses, its fuel economy is tremendous. A typical instance is a test made by the Central Railroad of New Jersey last fall. A 60-ton oil-electric locomotive during seven days handled 431 cars, aggregating 14,164 tons. A steam engine in the same yard in the same time handled 430 cars, weighing 14,013 tons. The oil-electric burned 208 gallons of fuel oil and used 3 gallons of lubricating oil; the fuel oil cost $10.40 and the lubricant $1.50, a total oil cost of $11.98. The steam locomotive burned 9 tons of coal which cost $64.35 and spent $9.00 for the labor of handling coal and water, a total fuel cost of $73.35.

A similar test on the Long Island Railroad in which the oil-electric locomotive handled 1,124 cars and the steam 1,351, showed comparative costs for fuel, water, etc., of $30.50 and $106.70.

The magnitude of the savings, and the comparative reliability of the oil-electric have led to recent orders for 12 such machines for yard service on eastern roads.

Southern Pacific Oil Fuel Record

A saving of 2,362,129 barrels of fuel oil, in freight and passenger service on the Pacific Lines of the Southern Pacific Company from January 1, 1920, to December 31, 1925, is shown in a report made by Chief Fuel Supervisor J. N. Clark.

During those six years the fuel per thousand gross ton miles in freight service decreased from 15.47 to 12.43 gallons. The locomotive load increasing from 1,145 tons to 1,457 tons. In passenger service fuel decreased per passenger car mile from 1.11 to .99 gallons, the cars per locomotive mile increasing from 7.19 to 7.76.

During 1925 a saving of 377,178 barrels was made as compared with the year 1924. The freight consumption per thousand gross ton miles was reduced from 12.81 to 12.43 gallons, and passenger consumption from 1.00 to .99 gallons per passenger car mile. Passenger service was handicapped from showing a larger reduction because of faster train schedules during 1925.

In his report Mr. Clark states that "employees on all divisions are taking a keen interest in fuel oil conservation work and the fine showing made is in a large measure due to the spirit of co-operation between officers and employes in this important economy work."

Engine Terminal Layouts

Reports Presented at the Convention of the American Railway Engineering Association

Engine terminals are provided so that the mechanical forces may care for and repair engines and furnish the transportation forces a supply of engines in good condition. To maintain the supply, engines must be handled through the terminal in the shortest possible time, or additional engines assigned to the district.

The development of steam locomotives in weight and tractive power has been so rapid during the past 10 or 15 years as to make the engine terminal a particularly important field for investigation looking toward the effecting of economies. The rapid advance in locomotive design is evidenced by the increase in revenue tons hauled per train mile from 380 in 1910 to 632 in 1923, or about 66 per cent.

While the greater portion of the time an engine is at a locomotive terminal is due to the time necessary in making repairs or waiting for trains or crews, an improperly laid out terminal will not only retard the movement of engines at all times, but will increase the most of hostling, and in times of peak business may become the controlling factor in the amount of business which can be handled at a terminal.

In order that the time locomotives are held at a terminal may be reduced to a minimum the locomotive terminal itself must be coordinated with all other facilities so that the movement of engines may be orderly and expeditiously made from the time engine is detached from its train in the yard or at the station until it is again attached to a train, its fires cleaned, coal, water and sand taken, oiled, wiped, and any needed repairs made, ready in first-class condition, to haul its full tonnage rating to the next terminal.

While an engine terminal designed for the orderly and expeditious movement of engines should reduce the time required by the mechanical forces to a minimum, it should be also borne in mind that unless traffic conditions are such that the engines can be used as soon as available, no saving will be accomplished by shortening the terminal time, and that the layover of assigned engines is fixed by schedules.

In order that the engine terminal design may meet all the requirements of a particular location, the co-operation of the operating personnel is necessary.

In order that facilities for proper capacity and spacing may be provided, a thorough study of the traffic to be handled, both for the present and in the future, must be made, for which the following information is necessary:

- (a) Type and size of engines to be handled.
- (b) Number of locomotives handled in each direction daily by classes.
- (c) Schedule of arrival and departure of locomotives by classes.
- (d) Number arriving during peak period.
- (e) Time within which engines arriving must be hostled by classes.
- (f) Maximum number of engines on terminal at one time.
- (g) Number engines repaired daily by classes of work.
- (h) Number engines under repair at one time by classes of work.
- (i) Amount of fuel (coal or oil) issued daily.
- (j) Amount of water consumed daily.
- (k) Amount of sand consumed daily.
- (l) Number of men required to operate the terminal.

While the time required for the movement of an engine from the terminal entrance to the engine house will vary greatly, depending upon the climatic conditions, fuel used, the size of the engine, length of run, class of service and amount of work done at the particular terminal, and this must be determined for each specific location, an average for all will be approximately:

From Terminal Entrance to First Facility	5 min.
Outside Inspection	30 min.
Cleaning Fires	45 min.
Taking Coal, Sand and Water	15 min.
Outside Washing	15 min.
Onto Table—Turning and Into House	4 min.
	1 hr. 54 min.

The movement between facilities depends upon capacity of facility, number of men, etc.

With the above information, after making allowances for the probable increase in traffic, changes in operating conditions and methods, etc., a diagram can be drawn for each engine movement, and the capacity of each facility, spacing between facilities and the time required for hostling each engine determined. This will permit the designing and spacing of the various facilities of the terminal for the orderly movement of engines from the entrance to the house.

In view of the expenditure necessary to provide a modern engine terminal, no terminal should be designed without providing for future expansion, so that it may be made with minimum changes to the original plant.

After a thorough study as to requirements has been made, and the capacity of the various parts of the facility determined, the adequacy of different proposed sites can be determined, and a layout adapted to the topographical conditions made.

The selection of an economic site requires a study of many features, including:

1. Land value of every possible site for present and future requirements.
2. Cost of preparing site and of foundations.
3. Drainage, sewer disposal, water supply, electricity.
4. Relation to existing or proposed yards and to passenger or freight stations.
5. Labor supply, including housing facilities and transportation.
6. Fire protection.

A comparison of these items for various sites and their relative values will show often that the selection of the more expensive land will more than offset the decrease in locomotive terminal mileage, decrease of foundation work, elimination of employe trains, etc.

Track Layout

Unless there are sufficient engines handled to warrant duplicate coaling and ash facilities, all engines should enter the terminal proper at one point, but an emergency exit should be provided so that in case of derailment or other trouble at the main entrance the terminal will not be tied up.

The number of tracks required, spacing of facilities, etc., depends upon the traffic to be handled at the particular terminal. There should, however, be sufficient trackage to permit the prompt receipt of all engines immediately upon arrival, and the leads should be situated to provide for the free movement of engines to and from the yards with minimum interference with other movements or between inbound and outbound engines.

The layout should provide for the orderly movement of engines without reverse movement between the entrance and the turntable, regardless of the time of arrival of preferred engines. Crossovers should be so arranged that yard engines or others not requiring turning may have

their fires cleaned, and take coal and water without crossing the table.

There should be sufficient trackage in advance of each facility for the standing of all locomotives which may have to wait their turn, so that they will not interfere with the movement of other engines or trains. Where climatic conditions permit outside storage, sufficient trackage should be provided for engines ready for service, to reduce the size of the enginehouse to a minimum, and so it will not be necessary to overload the turntable during the peak outbound period.

Water columns serving all tracks should be located near the terminal entrance, but far enough from the entrance to permit all engines which arrive in a short period (15 to 30 minutes) to clear the main line. Water columns should be placed also near the turntable, so that engines housed or stored for long periods may take water without moving the entire length of the terminal.

Inspection Pits

Where climatic conditions are favorable, and the type of repairs warrant, inspection pits near the terminal entrance will allow a preliminary inspection before the locomotive reaches the enginehouse, and advance notice given to the foreman of the work to be done. Such a pit should result in keeping a large percentage of the engines out of the enginehouse, particularly where there is a light repair shed.

The capacity required will depend upon whether the work is restricted to inspection, or whether running repairs are made on the pits, and the number of engines requiring inspection at one time.

All inbound, and under certain conditions, at least one outbound track should pass over the ash pit or pits, which should have sufficient capacity to take care of the peak period demand so that cleaning the fires will not delay the expeditious movement of engines throughout the terminal. Tracks should be so arranged, or pits so located, that preferred attention may be given to any engine regardless of its arrival time, and so that cinder cars may be loaded and switched with minimum interference to operation.

Pits should be designed and tracks so located that fire cleaners may work on both sides of the engines. There are several types of ash pits, all of which give satisfactory service, and in selecting a particular type, consideration must be given to: (a) The engine capacity required; (b) type and class of engine handled; (c) cinder storage capacity; (d) loading and switching of cinder cars; (e) cost of operation; (f) maintenance and construction, and (h) the supply of labor available.

At large terminals the mechanical type of coaling station, with track hopper and automatic elevating machinery is used generally. If a mechanical type station is selected, the track hopper should have sufficient capacity to handle one car without moving it, and the grade of the coal storage tracks such that the cars may be moved readily with a car puller. Unless provision is made for sufficient storage, or other means of coaling during a breakdown of the machinery, duplicate hoisting apparatus is recommended.

In selecting the type of coaling station, consideration should be given to the daily consumption; the various grades and kinds of coal; the source of supply; car supply; density of traffic during the winter season, and the desirability of having an emergency supply in storage at the terminal; the cost of switching; and the cost of construction and maintenance.

The coaling station should serve all inbound and outbound tracks and have bin storage capacity for thirty-six hours. Where different grades of coal are used it should be desined with separate bins for each grade.

Fuel oil delivery columns should be so placed so as to serve the same tracks as the water columns. In some cases there may be advantage in an arrangement which will permit taking oil and water on one spot. Unloading and storage facilities preferably should be far enough away from other facilities as to minimize fire risk. Economy in first cost and operation will be effected if this can be accomplished without duplication of pumping plant.

The sand house should have a capacity for a season's requirements, and be located near the sand bins. The dry sand bins may be constructed as a part of the coaling station, or on columns between tracks. The latter arrangement allows engines to take sand or coal without interference to other engines.

The pipe lines for blowing sand from the sand house to the bins should have a minimum number of bends and be built of extra heavy pipe. All tracks should be served by the sand bins, which, if not a part of the coaling station, should be placed between it and the wash platform.

Where weather conditions are suitable washing locomotives with a spray system will reduce the cost of wiping and facilitate engine inspection and repairs. Washing should be the last operation before the locomotive goes on to the turntable, so all ashes, coal or sand may be removed.

Wash platform of wood, concrete or macadam, pitched to drain to catchbasins, will protect the roadbed against saturation, and should be placed under all the inbound tracks close to the turntable. A platform should accommodate at least one engine and be slightly longer than the engines. An elevated walk on both sides of every track, about the height of a locomotive deck, will enable a man to reach the top of the boiler, sand dome, etc., when washing.

Turntable

The turntable should be of sufficient length and strength to meet the extreme demands upon it, and should be equipped with mechancial means of turning.

All approach and departure tracks to and from the turntable should line across the table with the enginehouse tracks to permit moving dead engines or carloads of supplies into or out of the enginehouse conveniently. Sufficient tangent on all turntable approach tracks should be provided to allow trucks to straighten out before passing onto turntable.

There should be no facing point switches in the outbound tracks, but trailing spring switches can be used to advantage in the inbound tracks.

Regardless of the type of table selected (deck, through, or three-point bearing), adequate drainage must be provided, otherwise there is a possibility of the turntable becoming frozen into the pit during severe weather. There should be sufficient depth for snow and dirt to accumulate below the pedestal.

At many terminals the capacity of the entire plant is fixed by the turntable capacity, and it is recommended that, in determining the number of turntables required at a terminal, four minutes be allowed per engine for turning, including the time running onto and off of the table, or fifteen engines (7½ dispatched) turned every hour. While this speed is, and must frequently be, exceeded during certain periods, the average speed should not greatly exceed this.

Enginehouse

The enginehouse should be twenty feet greater in depth than the longest engine to be housed, to allow working space at each end. Where, however, several classes of en-

gines are handled, different length sections to accommodate each class will decrease first costs. As the efficiency of the enginehouse force will depend upon the lighting, heating and ventilation, these features should receive particular attention.

The number of enginehouse stalls required, and the number of stalls per turntable, is dependent upon the class of repairs to be made and the time engines will be held in the house. This will require the study not only of the particular terminal, but also of the class of repairs made at other terminals to which the locomotives run, and consideration as to where the work can be done with the least detention to locomotives, the number of assigned engines for which it is the home terminal, number of short turn engines, and other considerations.

The equipment of the enginehouse for repair work will depend entirely upon the repairs to be made, but provision should be made for dropping wheels, changing side rods, and other heavy work. Steam, air and water should be piped to every pit for use in repairing engines, boiler washing, and firing up. Motor driven fans for firing up engines are being used at some points.

Wash rooms, toilet and locker facilities for the enginehouse force should be placed in that building, or closely adjacent, as should also the fan room of the hot-blast heating system if used.

Office and Dispatchers' Building

Adequate office facilities should be provided for the officer in charge of the terminal, and at a terminal handling seventy-five or more engines a day a separate building should be constructed, in which the crew dispatchers also should have quarters. This building should be adjacent to the enginehouse and so situated that the officer in charge may see the entire terminal from his office window, as should the crew dispatchers also. Rest room, locker and wash rooms for the engine crews, and if there is no Y. M. C. A., sleeping quarters for some engine crews may also be placed in this building.

The storehouse should be centrally situated for serving both the enginehouse and shop, to reduce the time required in obtaining material. Oil and other inflammable liquids should be kept below ground and pumped as required.

The size of this building will depend upon the kind of repair work done at the terminal, and the amount of stock to be kept on hand. This will involve a study not only of the class of repairs made at the other terminals to which the locomotives run, but also a study of the amount of stock carried at such terminals, and the time necessary to obtain material from them or a central store point.

The oil and lantern building, of fireproof construction, should be near the turntable where engine supplies can be obtained conveniently, and should be separate from the general store building, to provide more convenient access for engine crews and decrease fire hazard.

The power house should be centrally situated for supplying steam and hot water to the various buildings with minimum loss by radiation. The size of the building will depend upon the equipment installed, boilers, air compressors, boiler washing equipment, generating equipment, and switch board.

The entire terminal should be lighted artificially, with lights so placed as to facilitate particularly cleaning fires, taking coal, water and sand, and turning engines, without throwing a glaring light into the eyes of the engine runners.

Every office and building should be connected by telephone with the engine dispatcher, who should also have telephone connection with the yard office, towers and train dispatchers. A sufficient number of telephone lines should be installed to prevent overloading and to permit quick communication with any other party.

If the class of repairs to be made requires a shop, it should be at the rear of the enginehouse, and the tracks should pass through the enginehouse into it. This will allow engines to be dumped in the house and then pushed into the shop. The shop track should be double-ended if possible, to permit the movement of engines without unnecessary switching. Toilet, washing and locker facilities should be provided at the shop for all employes.

Depending upon the relative amount of light repair work, and determined from an actual performance record, a light running repair shed near the enginehouse may be justified to permit handling light repairs outside the enginehouse. This building should have double end tracks, with pits its entire length. The building should be lighted with natural and artificial light, and provided with steam and air. Such a building for tightening and testing will reserve the higher priced floor space in the enginehouse proper for heavy running repairs, and should be placed near both the enginehouse and shop, where parts are available and supervision made easy.

The boiler washing system should be in the power house, with tanks immediately adjacent, and piped to each enginehouse pit.

Fire hydrants, with hose houses and equipment, should be placed at strategic points on the terminal so as to provide at least two streams of water on any structure. Mains and hydrants should be located with due regard to future expansion of the terminal. It is recommended that pipe lines be built in loops so as to give even pressure at all points.

Conclusions

1—In designing an engine terminal layout, a thorough study of traffic and operating requirements of the terminal should be made jointly by the engineering, operating and mechanical departments.

2—A terminal should be designed, not only for present requirements, but also to permit future expansion.

3—Sufficient and properly laid out tracks should be provided to allow the prompt receipt of all engines immediately upon arrival, and in advance of each facility, for standing locomotives which may have to wait their turn, so arranged to allow orderly and expeditious movement of engines between the terminal entrance and the house.

4—The required facilities should be placed in proper sequence.

The Ventilation and Heating of Engine Houses

The following are recommendations for general practice in the ventilation and heating of enginehouses. They do not apply to houses which are equipped with mechanical systems for smoke removal consisting of special jacks, ducts, fans and stack. Such a system is not recommended for general use in connection with ventilation.

Smoke Jacks

Smoke jacks should be of the fixed type, at least 42 in. wide, and of such length (preferably at least 12 ft.) as to receive the smoke from stack at its limiting positions, due to the adjustment of the driving wheels to bring the side rods in proper position for repairs. The position of the jacks in the roof should be established with the above condition in view and the elevation of bottom of hood should be 16 ft. 6 in. at ends and 15 ft. 6 in. at sides above

top of rail. The area of flue opening should be at least seven square feet. An annular space two inches wide should be provided around the flue. A locomotive entering the house should be spotted with smoke stack under jack as quickly as consistent with safe handling, and always should be kept in such position while under fire.

Steam Blowoff

A proper system of piping for blowing off steam from boilers should be installed in every enginehouse. Where possible the steam blown off should be used for heating purposes in connection with a boiler washing system, but in all cases discharge should be made outside the limits of the enginehouse. A ventilator of standard design and at least eighteen inches in diameter should be placed in the roof on the center of each stall and as nearly as possible over the center of steam dome of locomotive handled. This ventilator should have an extension if necessary so as to bring it above highest part of roof. If regular blowoff piping is temporarily out of service, arrangement should be made to blowoff through portable pipe into this ventilator and the blowing off of locomotives without such provision should be prohibited absolutely.

These features will reduce the necessity for other ventilation, but, as with the best of care in operation, some smoke and steam will escape, the following additional recommendations are considered essential.

Cross-Section of House

As modern enginehouses have stalls generally 100 feet or more in depth, at least one break should be made in roof and, if desirable, complete monitor may be installed. Such breaks or monitors should have pivoted sash or a combination of pivoted sash and fixed louvres, depending upon climate.

Framing

Roof framing should be such that the rafters directly supporting the sheathing or other roof surface are in radial lines and without pockets so as to permit the free passage of smoke to eaves. At the high eaves directly under roof sheathing, if climatic conditions will permit, a continuous opening of four to six inches should be provided to permit the escape of smoke and steam, particularly at breaks and in monitors.

Large windows should be provided in the outer walls with a generous provision of ventilating sections. As near a continuous row of these ventilating sash as practicable should be provided along the top of window.

Heating

The relation of the heating system to the ventilation of the enginehouse is of course apparent. The provision of a hot blast heating system with supply of air taken either from outside or inside of house as conditions may require and circulation by means of underground ducts with outlets in pits and along the outer wall just above floor level is recommended for general use. Such a system designed for frequent air changes will result in the rapid clearing of atmosphere in house even under unfavorable conditions. The use of this equipment during the summer months will materially lower the temperature in the house as well as clear the athmosphere in same.

The Oil-Electric Locomotive Enters Manhattan Island

By C. B. KEYES, Manager of Railway Department, General Electric Company

For a number of years railway designing engineers have seen the desirability of the oil-electric type of motive power, and some nine or ten years ago the General Electric Company built a locomotive using an oil engine of its own design and manufacture. This locomotive was placed in service on the Jay Street Terminal Railroad in New York City in 1917. This was during the war period, when conditions were such that they reacted against the success of this particular installation. In fact, very little interest was shown in the locomotive at that time. It was a start, however. Later, a locomotive was built in co-operation with the Ingersoll-Rand Company, and equipped with a 300-horsepower Ingersoll-Rand oil engine. In 1923, when this locomotive was placed in service on the West Side tracks of the New York Central, operating between the 30 Street yards and St. John's Park in Manhattan, it created a great deal of interest among the railroads.

Representatives of some roads traveled half way across the continent to see this locomotive in operation. In fact, the time for demonstrating such a type of locomotive could not have been better, inasmuch as the railroads had just about succeeded in restoring their motive power to such a condition that they had time for the consideration of new developments, looking toward lower cost of operation.

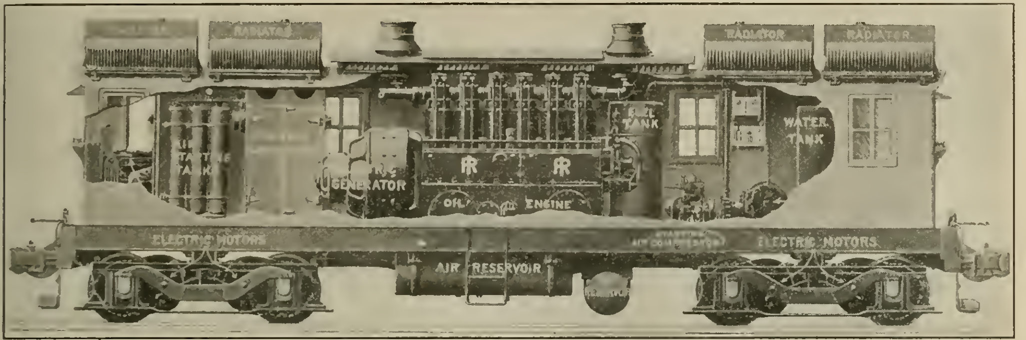
Later in the year this demonstration locomotive was given a tryout in the yards of most of the railroads operating in and around New York City. These operations demonstrated the reliability as well as the efficiency of the locomotive, which received most favorable consideration from not only operating officials but engine men and train crews.

Meanwhile the state of New York, in 1923, enacted what is known as the Kaufman Act. This law, as amended in 1924, provides that no railroad or part thereof operating within the limits of the City of New York or within the limits of an adjoining city shall on or after January 1, 1926, use any motive power in its operation within these cities except electricity, to be generated, transmitted and used in said operation in a manner to be approved by the public service commission. This act was very far-reaching and affected a number of the railroads, some with major operations and others with only minor operations within the territory involved.

To one not familiar with the handling of freight in New York, it will undoubtedly be surprising to learn the number of small freight yards and terminals scattered about the city. Some of these yards cover an area of only a block or two, each yard as a rule being served by a single locomotive. The majority of the yards are on the water front, and cars are brought to the yards on floats. The function of the locomotives is to take the cars to and from the floats and to spot them in the yards.

At the time of the adoption of the Kaufman Act and for a considerable time thereafter, the general impression seemed to be that it was not intended that it should apply to the small yards just mentioned; but as the railroads came to a realization of their real status under the new law, they began to consider plans for some type of motive

power that would replace their steam locomotives and comply with the act. In view of the fact that within the year practically all these roads had witnessed the demonstration of an oil-electric locomotive which met all their requirements as far as operation was concerned, and which operated at a lower cost than the steam locomotive, it is not at all surprising that they should have considered using this new type of motive power. Therefore, plans were filed with the public service commission on the basis of using this type of locomotive. When these plans were approved, orders were placed for locomotives and some of them are now in operation. The roads that are now using this type of motive power and those that are planning to do so, and the location of their yards, are as follows:



Phantom View of Oil-Electric Switching Locomotive

Baltimore & Ohio: One 60-ton locomotive, for 26th Street, Manhattan freight terminal.

Lehigh Valley: Two 60-ton locomotives, one for the 27th Street, Manhattan, and one for the 149th Street, Bronx, terminals.

Delaware, Lackawanna and Western: Two 60-ton locomotives, one for the Harlem transfer and one for the 25th Street, Brooklyn, terminal.

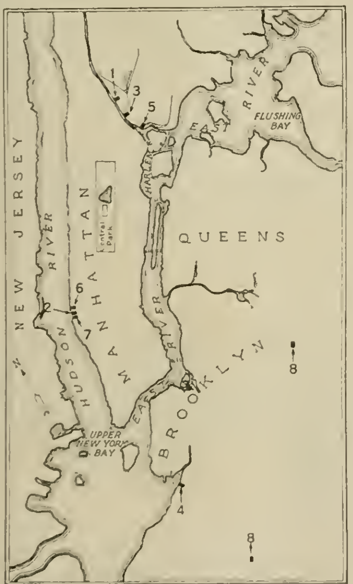
Central Railroad of New Jersey: One 60-ton locomotive for the Bronx freight terminal.

Erie Railroad: One 60-ton locomotive for 28th Street, Manhattan.

Long Island Railroad: One 100-ton locomotive, for Manhattan Beach and Evergreen Branch.

In addition to the above freight terminal installations, the New York Central Railroad has ordered one 800-horsepower (approximately 150-ton) passenger locomotive and one 750-horsepower (approximately 125-ton) freight locomotive to try out on the Putnam Division.

Of the locomotives mentioned above, all but two are equipped with oil engines of Ingersoll-Rand manufacture. The 800-horsepower passenger locomotive and one of the Lehigh Valley switching locomotives will be equipped with McIntosh and Seymour engines. The electrical equipment of all of the locomotives, including generators, motors, control, etc., is of General Electric Manufacture. The chassis, cab, etc., are built by the American Locomotive Company.



The Oil-Electric Has Replaced Steam Locomotives at the Following Locations:

1—Lehigh Valley—East 149th Street, Bronx; 2—Lehigh Valley—27th Street, Manhattan; 3—Delaware, Lackawanna and Western—Harlem Transfer; 4—Delaware, Lackawanna and Western—25th Street, Brooklyn Terminal; 5—Central Railroad of New Jersey—Bronx Terminal; 6—Erie Railroad—28th Street Terminal, Manhattan; 7—Baltimore and Ohio Railroad—26th Street, Manhattan; 8—Long Island Railroad—Manhattan Beach and Evergreen Branches

Pennsylvania to Extend Suburban Electrification

The Pennsylvania plans early electrification of its lines between Philadelphia, Pa., and Wilmington, Del., and between Philadelphia and West Chester, Pa., via Media. Work on this step in carrying out the program for the ultimate electrification of all suburban lines in the Philadelphia district will be started soon and is scheduled for completion in 1927. It is estimated that the total cost will approximate $10,000,000 exclusive of new electrically equipped cars which will be required.

Electrification of the lines to Wilmington and West Chester is an integral feature of the development of the new passenger station project on the west bank of the Schuylkill river and the subway extension and subway station for suburban traffic at Fifteenth street and the Parkway, Philadelphia. The total number of miles of line to be electrified will be about 52 and the total number of miles of track will be about 150.

Eight-Coupled Switching Locomotives for the Texas & Pacific Railway

Fitted With a Booster on the Tender for Heavy Hump Service

One of the most notable features of locomotive development, during recent years, has been the improvement in the design of switching locomotives, with a view of increasing their capacity and efficiency. The present day heavy switcher is specially designed for the work to be done, and is equipped with the same fuel and labor saving devices which have been used, with conspicuous success, in high-powered locomotives for road service.

The Baldwin Locomotive Works has recently completed ten such engines for the Texas & Pacific Railway. The design was the joint work of the railway company's motive power department and the builders, and was supervised by Mr. A. P. Prendergast, mechanical superintendent of the Texas & Pacific. The locomotives have 0-8-0 wheel arrangement, and although not the heaviest of their type, are designed to develop maximum power output within the weight limitations imposed. They are built to operate on curves as sharp as 32 degrees and grades up to 3 per cent, and develop a rated tractive force of 54,500 pounds. Two of the locomotives are equipped with boosters applied to the forward tender truck giving these engines a total maximum tractive force of 69,500 pounds.

Eight-Wheel Switching Locomotive for the Texas & Pacific Railway--Built by the Baldwin Locomotive Works

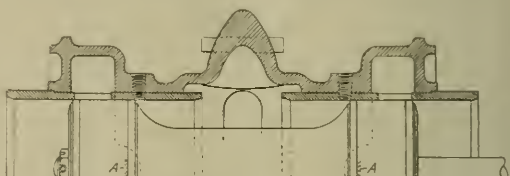
An important feature of these locomotives is the limited maximum cut-off with starting ports. The Pennsylvania Railroad has used this construction for a number of years in heavy road engines and more recently has incorporated it in the design of eight-wheel switchers. It has also been applied to road engines for the Texas & Pacific and other roads.

In the Texas & Pacific switchers the cut-off is limited to 65 per cent of the stroke. As locomotives of this type operate a longer part of the time in full gear cut-off, it is evident that limiting the maximum cut-off must result in a very high economy in the use of fuel and water. The starting ports, which are an essential feature of the limited cut-off, provide means for readily and quickly starting the locomotive in either direction. Compensating ports are also provided in the head end of the valve bushing. The function of these ports is to lengthen slightly the cut-off on the head end of the cylinder, thereby increasing the tractive effort without a corresponding decrease in the minimum factor of adhesion.

Plugs are provided in the side of the steam chest opposite the starting ports for cleaning purposes, and the arrangement of the ports and starting slots A are as shown on the engraving of the longitudinal section of the cylinder and steam chest. The valves are set with a maximum travel of 8¾ in., the steam lap is 2½ in., the exhaust lap is ⅛ in., the lead is ⅛ in., and the steam distribution is controlled by the valve motion of the Baker type, operated by a power reverse mechanism.

The cylinders are of cast steel with outside exhaust passages, each cylinder being made in one piece, with a half saddle. The cylinder barrels are bushed with gun iron. Effective lubrication at all times is assured by the use of both a hydrostatic and a mechanical lubricator.

Machinery details include piston heads of rolled steel, with gun iron bull rings; piston rods of normalized carbon vanadium steel; and crank pins and valve gear forgings, with the exception of the eccentric rods, of the same material. The main crank pins are hollow bored. The cross heads are of the alligator type, with chrome vanadium steel keys; and the guides and guide yoke are of most substantial construction, designed for severe service.



Longitudinal Section of Cylinders of Eight-Wheel Switching Locomotive for the Texas & Pacific Ry.

The main rods are of the articulated type, distributing

the load between the crank pins of the third and fourth pairs of driving wheels. Floating bronze bushings are used on the intermediate side rod connections. The main and side rods are of normalized carbon vanadium steel. Heat treated steel is used for the driving axles, which are hollow bored. The play between rails and flanges is 13/16 in. on the front and back drivers, and 9/16 in. on the intermediate and main pairs.

The frames are 5 inches wide, and special attention has been given to the transverse bracing in order to insure ample strength and preserve alinement in severe service. Fillets of liberal radius are used throughout, and each frame is cast in one piece with a single front rail of heavy section. The pedestal wedges are of the self-adjusting type.

The boiler has a straight top, and carries a working pressure of 250 pounds per sq. in. At present the locomotives are equipped for burning oil, but they are so designed that they can be readily modified to burn coal if desired. The Booth burner is applied, and the equipment is arranged in accordance with the railway company's standards. The firebox contains two thermic syphons.

Liberal use is made of flexible bolts in the firebox staying. There is a complete installation in the throat, and about 67 per cent of the bolts in the side water legs are flexible. In the back head, flexible bolts are used in the two outside rows and in the upper corners; and flexible crown bolts are placed in the three transverse rows at the front of the firebox, and in the three outside rows on each side of the top center line.

The throttle valve is placed in the smokebox, and is connected with the dome by an internal dry pipe having a shut-off valve at its rear end. With this arrangement, the superheater is filled with steam at all times, and superheated steam can be used for the auxiliaries. The superheater is of type "A" design, having 34 elements.

The boiler accessories include two steam turrets, one for saturated and one for superheated steam, which are both placed in front of the cab. All the valves have extension handles, properly labeled and conveniently located for the engine crew. The saturated steam turret has connections for the injectors, fire extinguishers, cab steam heat, squirt hose, and power reverse; while the superheated steam turret supplies the air pump, blower, headlight dynamo, and all oil burning steam connections. This turret is supplied by an outside steam pipe, placed on the left side of the boiler, and properly designed to allow for expansion.

The fire extinguisher, to which reference has been made, has two water inlets, one connected to the tank and the other to couple to a fire plug. Fifty feet of two-inch fire hose are provided.

The cab fittings were located under the personal supervision of Mr. R. W. Salisbury, mechanical engineer of the railway company, and the resulting arrangement is exceedingly convenient. The cab is steam heated, equipped with Lima seats and with a clothes locker for the crew. The tools are carried in a combination tool and sand box placed in the front of the tender tank.

A notable feature is the running boards, which are as straight, and placed as low down, as possible. This, in combination with a long, low tank gives the enginemen a clear view in both directions.

The tender has a commonwealth cast steel frame, made in one piece. The oil and water tanks have capacity for 3,000 and 9,500 gallons respectively, and in the event of changing to coal burning, 12 tons of coal can be carried in the fuel space.

As has been mentioned, the tenders of two of these locomotives are equipped with boosters furnished by the Franklin Railway Supply Company. The booster is mounted on the front truck, which is of rather unique design. It is made in one solid cast steel piece with a cross end piece to support the booster engine, similar to the familiar support of the booster on locomotive trailing trucks. A unique feature regarding the equalizing of this truck is that it is arranged so that a greater proportion of the load comes on the wheel that is directly driven by the booster, thereby relieving the side rods of all unnecessary strain. The truck frame and equalizers are illustrated in Figure 1, while Figure 2 shows the complete

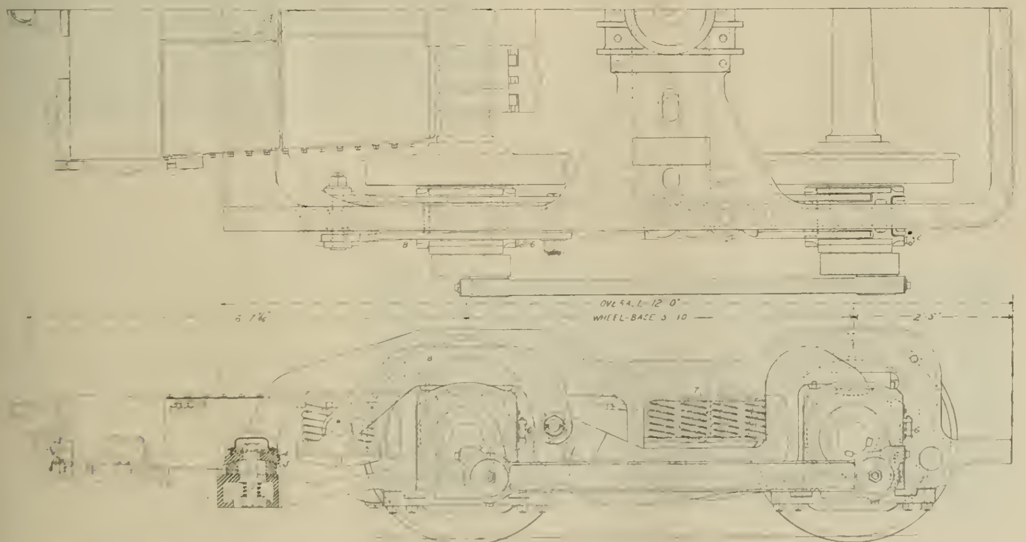


Fig. 1—Plain and Side Elevation of Booster Truck of Eight-Wheel Switching Locomotive for the Texas & Pacific Ry.

truck with the booster mounted thereon, and the line engraving of the plan and side elevation gives a general idea of the dimensions of the whole unit. This arrangement provides great accessibility for any attention that the booster engine may need.

Referring to the line engraving the attachments, shown at the side of the cylinder are cylinders for the operation of the cylinder cocks. The support of the booster engine cylinders is shown in section at *2*. As the crank end of the engine rests directly upon the axle without any spring support similar to the motor of an electric car, while the cylinder end rests upon the end piece of the truck, which is spring supported, provision had to be made for variations in alinement between these two points of support. This is accomplished by means of the spherical joint shown in section. This is located at the transverse center and the bearing proper consists of the two parts 3 and 4. The lower convex portion 3 is regidly attached to the truck, while the upper part, 4, is fastened to the engine bed. The two are held together by the bolt 5. The tension on this bolt is regulated by a helical spring so that it can yield as the upper portion of the spherical joint moves over the lower. With this arrangement the spring-supported portion of the engine is free to move up and down, and the axle-supported end can conform to the angular movement of the axle, relatively to the truck frame, due to irregularities in the truck, without putting any stress upon the connecting parts other than that required for the compression of the spring under the nut of the bolt 5.

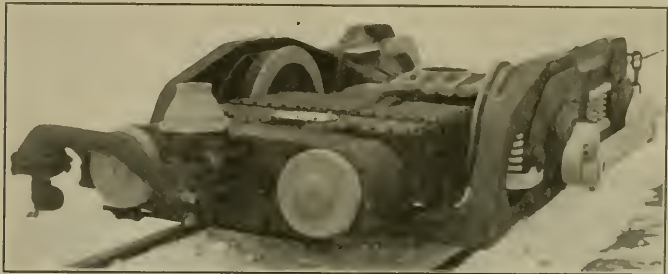
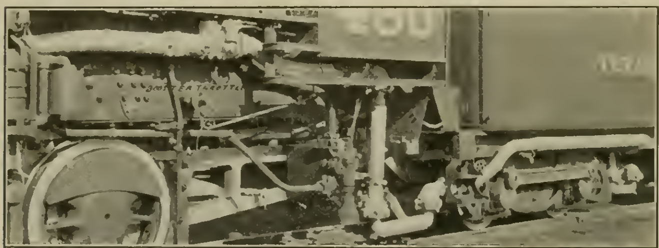


Fig. 2—Booster Truck of Eight-Wheel Switching Locomotive for the Texas & Pacific Ry.



Side View Showing Piping Arrangement for the Booster of the Eight-Wheel Switching Locomotive for the Texas & Pacific Ry.

Reference has already been made to the unequal distribution of the weight on the two axles. This is accounted for by the overhang of the engine cylinders by which the greater portion of its weight is carried on the spherical bearing 2. The greater portion of the weight of the tender frame and tank, bearing on the motor truck is carried by the front or idle wheels. The wheel base is 5 ft. 10 in. and the bolster center is set 3 ft. 1 in. from the driving wheel centers and 2 ft. 9 in. from that of the idle wheels. Then the nest of equalizer springs 7, is set with its center 2 ft. 2 in. from the idle wheels and 3 ft. 8 in. from the driving wheels making the ratio of supports as 13 to 22. This load is equalized over the driving axle by the equalizer 8, the outer arm of which is 23 in. long and the inner 15¾ in.

The truck is fitted with 36 in. wheels and the journals measure 9 in. x 12 in. These are ordinary surface bearings lubricated in the standard manner as is customary with tender trucks and shown by the grease cups at 6. The cellars are so arranged that by merely removing the pedestal tie bars, they can be removed for repacking.

The side rods which are clearly shown are made of carbon vanadium steel. The booster is piped to take superheated steam under the control of the main engine throttle, supplemented by the regular automatic booster control. The piping is shown clearly in the illustration.

The booster exhaust is arranged so that it can be discharged either into the atmosphere or into the tender water tank. Thus it is possible to recover some of the heat units in the exhaust steam of the booster.

Side View of the Booster Tender of the Switching Locomotive for the Texas & Pacific Ry.

With the use of the booster, the maximum tractive force of the locomotive alone, amounting to 54,500 pounds, can be increased by 15,000 pounds. This fits these locomotives especially for hump yard service, or for work where inclines are encountered and exceptionally high tractive force must be exerted for short periods of time. Under such conditions, the boiler power is sufficient to furnish steam to both the main cylinders and the booster.

This is the first application of this type of tender booster and we hope to publish a report of its performance in a future issue.

The accompanying table of dimensions gives further particulars of these locomotives.

Cylinder diameter	22 in.
Piston stroke	28 in.
Diameter of boiler	78 in.
Working pressure	250 lbs.
Fuel	Oil
Firebox staying	Radial
" length	102 1/16 in.
" width	75¼ in.
" depth, front	75½ in.
" depth, back	73½ in.

Tubes diameter		5½ in. & 2 in.
" number		199
" " (superheater)		34
" length		15 ft.
Heating surface firebox		176 sq. ft.
" " tubes		2284 sq. ft
" " thermic syphons		55 sq. ft.
" " total		2515 sq. ft.
" " superheater		574 sq. ft.
Grate area		53.4 sq. ft.
Driving wheels, diameter		51 in.
Tender " "		36 in.
Wheel base, driving		15 ft. 0 in.
" " engine and tender		55 ft. 4½ in.
Weight in working order:		
Driving wheels		230,870 lbs.
Engine and tender		428,000 lbs.
Water tank capacity		9,500 gals.
Oil " "		3,000 gals.
Tractive effort		54,000 lbs.
" " with booster		69,500 lbs.

New Equipment Much More Efficient Than Old

A total of 10,105 new locomotives have been installed on the railroads during the past four years, and in the same period 10,962 were retired. Thus there was a net decrease of 857 in the number of units during the four-year period.

These facts are brought out in an analysis of the railroad equipment situation just completed by Dr. Julius H. Parmelee, Director, Bureau of Railway Economics. Dr. Parmelee says in part:

"This apparent decrease in motive power does not, however, tell the story, inasmuch as the new locomotives were of greater weight and far greater power than those retired. The final result, in terms of aggregate tractive power, was a net increase from the beginning of 1922 to the end of 1925 amounting to 207,203,000 pounds, while the increase in average tractive power per locomotive was from 36,935 pounds in 1922 to 40,625 pounds in 1925. In other words, although the number of units decreased, the amount of available tractive power increased.

"The extent to which the addition of larger and more powerful locomotives has offset the retirement of older, smaller and less powerful types, is well illustrated by reference to the figures of installations and retirements in 1925. In that year a total of 3,005 locomotives were retired, while only 1,733 new units were installed. Yet the aggregate tractive power of the new units nearly equalled the aggregate power of the retirements, due to the much greater average power of the new locomotives. The 3,005 locomotives retired had an average power of 32,394 pounds each, or an aggregate of 97,344,562 pounds; the 1,733 locomotives installed had an average power of 52,798 pounds, or an aggregate of 91,499,557 pounds.

"In the case of freight cars, a larger number were installed than retired during the four years ending with 1925. According to the table the net increase was approximately 43,000 cars. As was true of the motive power during the same period, this comparatively small net increase in freight car units by no means indicates the extent to which the railways replaced smaller types of worn out and obsolete freight cars by larger types of modern and up-to-date cars. The net result of the large program of car retirement and replacement carried out by the railways during the four years was an increase in aggregate freight car capacity of 6,986,000 tons, and an increase in average capacity per car from 42.5 tons to approximately 44.7 tons.

"Here again, as in the case of the locomotives, the new cars were of greater average capacity than those retired. The result was that the net increase in aggregate freight car capacity was relatively greater than the increase in units. In 1925, for example, the 117,021 freight cars retired had an average capacity of 38.77 tons, or an aggregate of 4,537,287 tons; the 125,760 cars installed had an average capacity of 47.37 tons, or an aggregate of 5,956,930 tons. The net gain in car units during 1925 was only 8,739; the net gain in aggregate capacity was 1,419,643 tons.

"The number of passenger-train cars installed and retired during the past four years is also shown in the table. While the number installed exceeded the number retired by a comparatively small margin, yet the newer units were generally of better and larger construction than the older ones retired. The totals for the four years were 9,298 cars installed, and 9,057 cars retired."

The following table shows the equipment installed and retired by the Class 1 roads from 1922 to 1925 inclusive:

NUMBER OF UNITS INSTALLED

	Locomotives	Freight train cars	Passenger train cars
1922	1,226	105,394	1,328
1923	4,360	232,060	2,658
1924	2,786	155,893	2,755
1925	1,733	125,760	2,557
Total—4 years	10,105	619,107	9,298

NUMBER OF UNITS RETIRED

	Locomotives	Freight train cars	Passenger train cars
1922	1,682	126,471	1,286
1923	3,746	213,789	2,360
1924	2,529	118,441	2,293
1925	3,005	117,021	3,118
Total—4 years	10,962	575,722	9,057

Reclaiming Coke from Locomotive Ashes

A plant for reclaiming coke from locomotive ashes is to be constructed by the Boston & Maine Railroad at East Somerville, Mass., adjacent to its enginehouse and shops. It is expected that the railroad will be able to obtain in this manner practically all the fuel required for station heating. Present station requirements aggregate approximately 30,000 tons a year.

This project, so far as known the first of its kind by any railroad in this country, will recover from the locomotive waste now dumped into ash heaps unburned coke which tests have shown to average from thirty-three to forty per cent of the ash. The Boston & Maine expects to recover approximately thirty per cent by the new process.

This process is an adaptation of one used in the hard coal fields for separating impurities. It is based on the comparative specific gravity, and by means of water flotation the coke is segregated and the cinder residue precipitated.

The new plant will cover an area approximately 30 x 100 ft. It will cost about $50,000 and will handle 2,000 tons of ashes weekly, from which approximately 600 tons of coke are expected to be reclaimed. It has been found that a considerable quantity of combustible coke is taken from fire boxes in the cleaning of locomotives after each trip, and this unburned material is expected to make up a large part of the new product.

The cinders to be handled by the new plant will be largely those dumped from locomotives in Boston enginehouses and shops, but if the results warrant, the reclamation process may be extended to apply to the ashes from locomotives elsewhere on the system.

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The Utilization of Motor Cars

It is an old saying that the man out of a dilemma always knows what the man in it ought to do. And as a corollary to this it is evidently unsafe to criticize anyman's actions until all of the conditions with which he is surrounded are known.

It is, therefore, with a full recognition of the possibilities of a mistaken judgment that a criticism is offered on the failure of railroad companies to take and to have taken full advantage of the facilities offered by the direct-driven and gas-electric cars that are upon the market and of which the description of a notable example is published in another column.

There are, it is well known, very many of these cars in service throughout the country and in some instances the whole of the passenger service on some rather long lines is handled exclusively by these cars. The wonderment is that there are not more of them and that they have not been used to forestall and prevent the construction of competing electric railroads and the establishment of paralleling bus lines.

To illustrate the point by a concrete case, there is in one of the mid-western states a railroad, operated as an auxiliary of one of the main trunk lines, having a length of about two hundred miles. At each end there is a large city, and scattered along its line there are other minor cities having large manufacturing interests. It is a single track line having a light passenger and freight traffic, over which four passenger trains are operated each way daily. As one of these trains is a night train covering the distance between late night and early morning, it offers no convenience for local traffic, leaving but three trains to handle that traffic.

As an example of the competition three points will be taken, A, B and C. A is a large city and one of the terminals. B and C are large manufacturing centers. It is about sixty miles from A to B and about seventy from B to C. A and B are served by three railroads whose trains, number eighteen in all each way daily, afford such a choice and such service that a competing electric line has never been built, though the motor-bus is thriving on the local traffic. But from B to C the single track line with its three daily trains is all the convenience that the steam road offers. The result is the expected one. An electric line has been built paralleling the steam road, giving good hourly service in high grade fast running cars that are operated for most of the time to capacity. It runs, to be sure, on the public highway for a good part of the distance, but so close to the steam railroad, that the latter could have afforded every facility and convenience of the electric road, had it seen fit to put on the motor car, and the investment in a full equipment to have given an hourly service would have cost but little more than the rolling stock equipment of the electric road and would have saved all of the overhead cost of the roadway and electrical equipment. The reason why it was not done is probably to be found in the inertia of a board of directors six hundred miles away coupled to their ignorance of local conditions, while the competing electric road owes its existence to the drive of men on the spot who were fully cognizant of the local possibilities and took advantage of the sleepy indifference of the railroad officials to develop a traffic that those same officials did not dream existed but which they might have controlled.

On the other hand such a forestalling or meeting of competition may be prevented by traffic conditions that do not admit of intercalating a frequent motor car service in between freight trains, but when the importance of the traffic that it is possible to develop is considered it would seem worth while to bend every effort to such a modification of conditions as to be able to accommodate this intercallation.

There are hundreds of cases similar to the one cited, where cheaply operated motor cars could be used to forestall or meet competition. And it would not always be necessary to install such a high grade car as that seventy-three-foot car de luxe of the Boston & Maine.

In RAILWAY & LOCOMOTIVE ENGINEERING for December, 1924, a cheap train in use on one of the Chilean railroads was described. This consisted of a Ford car fitted with flanged wheels for track work and hauling a small trailer. It is hardly probable that the whole outfit would cost more than four or five thousand dollars in this country, and it could be made as comfortable and convenient as the average electric car and would serve an admirable purpose in retaining traffic for the railroads that will otherwise pass to a motor bus or a paralleling electric line.

There is a sort of glamor attached to a motor-bus trip that makes the passenger fancy, at first, that he is traveling in some semblance to a private automobile, but for a long run the fatigue incurred in the bus so greatly exceeds that in a car on rails, that the latter would soon come into its own if it afforded the same facilities as to frequency of operation.

As already acknowledged, adverse criticism of this sort is a hazardous pastime, but it does seem that with their invested capital in a roadway already built, that it is the fault of the lack of foresight of the railways themselves if, by the use of suitable motor cars, giving a service that is demanded, they do not hold and develop for themselves all of the traffic that a territory is capable of sustaining.

Industrial Wars and Their Costs

Elsewhere in this issue will be found some rather interesting figures on strikes and their cost to the parties at interest, particularly those who had to do with or may have been any way interested in the shopmen's strike of July 1, 1922.

The tabulation in the article in question shows the repair costs per engine per year and the cost per mile run in 1921, the year prior to the strike and 1924 the second year thereafter. While this is not only interesting and in a measure reflects the various elements of facilities, resourcefulness, managerial ability, etc., brought into play in getting back to normalcy, yet through the omission of the figures for 1923, when the cost of the strike was fairly reflected in the maximum expenditures and bringing up arrears in repairs, the full measure of what was actually accomplished is not as clearly brought out as it might and should be.

The following tabulation when studied in connection with the one on page 111 will bring out this point.

are so closely interwoven with their own, that it would seem almost impossible for another such calamity to occur where the parties at interest are willing to listen to reason.

These displays abound with lessons in finance, civic pride, efficiency and economy.

Railway Accidents Show Decrease

Casualties resulting from train and train service accidents on the railroads of the United States in the eleven months ending November, 1925, show a decrease of 641 as compared with the first eleven months of 1924.

One of the outstanding features of this performance, as shown in reports compiled by the Bureau of Statistics of the Interstate Commerce Commission, was the steady improvement in the safety of passenger service.

Passenger casualties for the first eleven months of 1925 showed a decrease of 517 as compared with the corresponding period of the preceding year. Passenger casualities per one million locomotive miles decreased from 3.27 in 1924 to 2.90 in 1925.

	Number locomotives, average tractive power, mileage made and cost to repair.					
ROADS (1923)	Mileage Operated	Number Locos.	Average Tractive Power	Average miles all Service	Repairs per eng. in Serv.	In cents per mile in Serv.
Boston & Maine	2,287	1,121	28,892	23,047	$9,671	42.0
Bangor & Aroostook	616	89	26,410	21,814	4,280	19.6
Maine Central	1,208	235	31,463	28,390	6,266	22.1
Central Vermont	468	109	33,203	28,719	6,649	23.2
A. C. L.	4,866	939	29,466	27,661	6,125	22.1
S. A. L.	3,572	600	35,779	30,621	7,039	23.0
Southern	6,971	1,738	39,312	27,642	7,326	26.5
Central of Georgia	1,921	334	36,894	31,166	6,807	21.8
Illinois Central	6,226	1,901	38,944	32,209	8,545	26.5
Cotton Belt	1,777	291	33,488	23,085	7,912	34.3
M. K. & T.	3,203	590	39,887	21,784	10,202	46.8
Texas & Pacific	1,953	331	34,457	23,767	10,249	43.1
Southern Pacific	7,138	1,750	38,350	33,818	9,007	26.6
Northern Pacific	6,669	1,407	37,943	21,716	5,160	23.8
Great Northern	8,251	1,419	40,682	23,233	5,678	24.4
St. Paul	10,990	2,162	36,358	26,132	6,824	26.1
B. & O.	5,304	2,593	45,584	28,623	9,770	34.1
Lackawanna	953	762	34,331	27,667	11,240	40.6
Burlington	9,406	1,963	36,090	27,624	7,871	28.5
Chicago & N. W.	8,463	2,115	34,360	25,617	6,915	27.0
Total and Averages	96,382	22,449	35,595	26,717	7,677	29.1

Tabulated display cost of repairs per unit in service, in dollars per year and cents per mile on twenty (20) railways for the year 1923, which reflects the aftermath or results of bringing up arrears in repairs following the shop men's strike of July 1st, 1922.

It will be observed that the lowest cost per unit in 1923 was $4.280 and 19.6 cents per mile run, while the highest was $11.240 and 46.8 cents per mile. The average for the 20 lines, geographically distributed over the United States is $7.677 per unit and 29.1 cents per mile run.

Five hundred million dollars is a pretty big price to pay for a lesson in economy and reason and it is to be hoped that another such condition may not again occur.

The wonderful prosperity and high prices which prevailed during the war period resulted in what might be termed financial intoxication. Individuals, corporations and societies and trade associations, particularly that class of persons or organizations that had almost suddenly been lifted up into an unusual or abnormally high atmosphere of finance and luxury, from which height or temporary position all sane, sober, fair minded persons knew there must be an orderly or disorderly recession as made necessary by the changed conditions.

Many thousands of worthy citizens whose individual losses contributed to the estimated sum of $140,000,000 will be more cautious in future to avoid an unwise ultimatum, so expensive and disastrous alike to themselves and their employers, whose interest in the last analysis

A decrease of 1,543 train accidents in the eleven-month period last year as compared with the preceding year was also shown in the report. This reflects the more careful management of trains as well as the increased efficiency of railroad maintenance work.

Liberal expenditures for maintenance work and continuous installation of new equipment and facilities, are an important part of the ceaseless effort of railway management to operate trains with the greatest possible safety to passengers and employes.

Under train accidents are classed those resulting from collisions, derailments, locomotive boiler and other locomotive accidents. Train service accidents include accidents from coupling or uncoupling trains, operating locomotives, hand brakes and switches, getting on and off locomotives, accidents at highway crossings, etc. The total number of casualties resulting from these two classes of accidents amounted to 48,855 for the first eleven months of 1925 as against 49,496 for the corresponding period of 1924.

Highway grade crossing accidents increased from 4,599 in the first eleven months of 1924 to 4,794 for the same period of 1925. Total casualties at highway grade crossings amounted to 7,646 in 1925, a decrease of 135.

Practically all accidents at highway grade crossings are automobile accidents. While steady progress is being made in the reduction of such accidents, constant care on the part of automobile drivers can substantially reduce this type of hazard.

The Oil-Electric Locomotive

Steam railroad officials throughout the country are showing increasing interest in the future of modern railroading in America in so far as it may be influenced by the development of the oil-electric locomotive. They have advanced this belief in 500 significant letters written during the last few weeks to the American Locomotive, General Electric and Ingersoll-Rand companies, combined producers of this type of locomotive. Out of these 500 letters written to the three companies by steam railroad heads, superintendents, chief engineers and master mechanics, a great majority expressed an active interest in the exploits of the oil-electric as a potent, future force in American railroading. Some went so far as to say that they looked to the day, when the oil-electric, because of its economy in cost of operation, would be the prevailing type of railroad motive power.

The frank comments of the steam railroad executives and officials, the letters disclose, were made after observations carried on for some months as to the essential efficiency and lower operating costs. As many phrased it, this new motive power promises a solution to transportation's most pressing problem—economy.

Many of the railroad executives wrote that they were watching the demonstrations of the oil-electric locomotive, during its eighteen months' service on American railroads, with the idea of installing this new motive power in trial tests upon their own systems. Others calculated the possibilities of the oil-electric locomotive when it is perfected beyond the 750 horse-power type now being built, to a 3,000 to 6,000 horse-power capacity.

In the letters the steam railroad men emphasized the advantages of the oil-electric as follows:

1.—The adaptability of the oil-electric to every phase of railroading, from the work of the switch engine to that of the freight and passenger locomotive, without change of equipment. This eliminates the expensive introduction of overhead trolleys or third rails.

2.—Its low cost of operation through the use of cheap fuel oil, as compared with the cost of coal as fuel, an estimated saving of 75 per cent.

3.—Further curtailment in operating time and costs through the ability of the oil-electric to start quickly and to accelerate on steep grades.

4.—Still further economy in time and expense, through the oil-electric's ability to run long distances without refueling. The fact that the oil-electric can make a transcontinental run without stopping to re-fuel is instanced as an appreciable time saver.

5.—Saving in fuel when the locomotive is not in use, the oil-electric requiring no banking of fires.

6.—Elimination of round-houses and repair shops throughout the railroad systems.

7.—Elimination of water towers and water tank cars, made possible through the use of only a small supply of water needed to cool the oil-electric engine.

8.—Vastly improved visibility afforded the engineer, since there are no obstructions ahead of the locomotive cab.

9.—By means of its simple control process—there are only two control levers in the oil-electric—the engineer is able to devote himself more freely to watching the road ahead, thus reducing the liability of accidents.

10.—Elimination of ash-heaps and coal dumps, with the economy of time and expense involved in their handling. The total maintenance cost of the oil-electric will result in a 50 per cent saving over that of the steam locomotive. The annual maintenance cost of the oil-electric is under $3,000.

11.—Elimination of tenders.

The oil-electric locomotive is now in use on four Eastern railroad systems, while five other Eastern and Mid-Western roads are awaiting their delivery.

Centennial of Mohawk and Hudson Railroad

On April 17, 1826, the Legislature of the State of New York granted a charter to the Mohawk and Hudson Railroad. On April 17, 1926, the New York Central Lines will celebrate the hundredth anniversary of the chartering of this old railroad, now an essential part of its main line.

The celebration will begin on the seventeen miles of railroad between Albany and Schenectady, N. Y., over which on August 9, 1831, the De Witt Clinton locomotive hauled its first train.

The New York Central Lines have invited a notable assembly of railroad executives, public officials and prominent citizens. Bronze tablets will be placed on the walls of the depots at Albany and Schenectady. Headed by the old De Witt Clinton locomotive and the stage coach cars which it pulled, a special train will proceed from Albany to Schenectady with a pageant of the various types of locotives from the De Witt Clinton on.

Returning to New York City, the commemoration will conclude with a banquet at the Hotel Waldorf-Astoria, at which the attendance will be 1,000. Hon. Chauncey M. Depew, Chairman of the Board of Directors of the New York Central Lines, will preside. P. E. Crowley, President of the New York Central Lines, Governor Smith, Mayor Walker and other important men will deliver addresses. The speeches will be broadcast beginning at 9:30 p. m., through Station "WJZ" and affiliated stations.

The Mohawk and Hudson Railroad started steam operation in 1831 with an American-built locomotive and has remained a steam railroad continuously from its opening trip. Many other early railroads began operation or experiment with steam power, but were compelled, at least occasionally, to revert to horses or mules; but the De Witt Clinton ran consistently until supplanted by other and better locomotives.

The original train attained a speed as high as thirty miles an hour on the level, and in its early trials negotiated the seventeen miles from Albany to Schenectady in thirty-eight minutes.

By 1843—twelve years after the opening of service between Albany and Schenectady—nine other small railroads were built, covering the gaps between Schenectady and Buffalo. It took twenty-five hours to make the journey and required nine changes of cars. In 1853 the first New York Central Railroad Company came into existence through the consolidation of these ten railroads into one continuous property under a single management. Subsequently, by consolidating with the Hudson River Railroad, running south from Albany to New York City, the New York Central and Hudson River Railroad was brought into being. This in turn, through the acquisition of connections to Chicago and St. Louis, became the New York Central Lines of today, with 12,000 miles of main line and an investment of about $2,000,000,000, and its employes numbering upward of 160,000. The system today has less than 5 per cent of the total railroad mileage of the United States, less than 10 per cent of total number of employes but moves about 11 per cent of the total traffic

Do We Profit from the Lessons of Industrial Wars

By W. E. SYMONS

When we speak of industrial war, more commonly called strikes, we scale down their costs usually to a few thousand dollars and a few human lives. There are, of course, exceptions in which the cost of a strike may run into millions of dollars and the sacrifice of quite a few lives.

Deplorable as all these conflicts may be they usually leave in their wake certain conditions that operate to the benefit of those most actively interested or affected by the conflict, and it therefore follows that regardless of the real merits of the points involved in controversy that certain "Blessings come in Disguise," in the wake or path of conflict.

Shop Men's Strike of 1922

When the railroad shopmen threatened a general strike in 1922 many predicted it would be a fizzle, but to the surprise of those who so prophesied, it was not only called but was 90 per cent effective. Many railway officers who were sure of their ability to hold practically all of their forces, except possibly a few "transients," suddenly found themselves without shop forces and in a short time the effect of this condition began to manifest itself in the deterioration of power and lowering of the standard of service.

NEW ENGLAND	Bangor and Aroostook		Boston and Maine		Central Vermont		Maine Central	
ITEMS	1921	1924	1921	1924	1921	1924	1921	1924
Number of engines	95	89	1,102	1,072	99	109	233	235
Aver. Cost of Repairs	$4,748	$5,039	$6,300	$6,507	$6,703	$4,301	$5,269	$5,088
Aver. cost cents per mile	23.6¢	24.2¢	29.9¢	32.2¢	29.1¢	18.7¢	21.4¢	19.8¢
Aver. tons per train	322	361	456	486	347	446	375	400
Cost per 1,000 ton miles	$2.16	$1,568	$1,994	$1,728	$2,273	$1,324	$2,252	$1,599
SOUTHEASTERN	Atlantic Coast Line		Central of Georgia		Seaboard Air Line		Southern Railway	
	1921	1924	1921	1924	1921	1924	1921	1924
Number of engines	901	939	316	334	577	600	1,819	1,738
Aver. cost of repairs	$6,418	$6,200	$5,394	$5,575	$5,173	$6,786	$5.088	$6,611
Aver. cost cents per mile	27.8¢	23.1¢	20.6¢	18.6¢	20.5¢	22.0¢	23.6¢	25.5¢
Aver. tons per train	429	507	474	499	430	496	461	508
Cost per 1,000 ton miles	$1,362	$1,013	$1,267	$.957	$1,572	$1,327	$1,577	$1,313
SOUTHWESTERN	Illinois Central		M. K. & T. R.R.		Cotton Belt		Texas & Pacific	
Number of engines	1,736	1,901	714	590	280	291	359	331
Aver. cost of repairs	$7,203	$7,016	$8,153	$6,435	$4,160	$5,382	$8,879	$7,571
Aver. cost cents per mile	26¢	24.6¢	35.5¢	27.9¢	19.6¢	25.8¢	36.2¢	30.2¢
Aver. tons per train	715	747	530	670	532	579	468	553
Cost per 1,000 ton miles	$.901	$.775	$1,228	$1,200	$1,075	$.924	$1,390	$1,094
NORTHWESTERN	St. Paul		Great Northern		Northern Pacific		Southern Pacific	
Number of engines	2,117	2,162	1,428	1,419	1,408	1,407	1,490	1,750
Aver. cost of repairs	$7,192	$6,163	$4,233	$4,506	$3,669	$4,232	$8,523	$7,533
Aver. cost cents per mile	31.9¢	25.8¢	22.2¢	21.3¢	19.8¢	21.1¢	29.0¢	25.2¢
Aver. tons per train	574	680	701	893	708	765	629	706
Cost per 1,000 ton miles	$1,348	$.957	$1,304	$.978	$.902	$1,024	$1,596	$1,197
CENTRAL	C. B. & Q. R.R.		C. & N.W. RY.		B. & O. R.R.		D. L. & W. R.R.	
Number of engines	2,016	1,963	2,036	2,115	2,500	2,593	756	762
Aver. cost of repairs	$6,080	$6,709	$6,340	$5,875	$7,332	$7,446	$6,817	$8,053
Aver. cost cents per mile	24.1¢	26.3¢	27.1¢	24.7¢	32.5¢	28.7¢	25.0¢	29.5¢
Aver. tons per train	717	746	479	522	753	833	765	773
Cost per 1,000 ton miles	$1,017	$.947	$1,290	$1,025	$1,260	$1,025	$1,362	$1,217

Tabulation Showing Selected Items of Cost on Twenty (20) Different Railways, One Year Before and Two Years After the Shopmen's Strike of 1922

What Did It Cost

Various estimates have been made as to the cost of the strike to all parties at interest, but most of them are wide of the mark in that they are much too low, being based as a rule on preliminary figures cast up in the fall of 1922, which included only reported losses up to that period. As a matter of fact the strike continued on many roads throughout 1922 and 1923, and with few exceptions the carriers were forced to expend during 1923 and well into 1924 millions of dollars in bringing up arrears in repairs due to the strike, all of which is chargeable to the account.

What might be considered a fair estimate of the principal factors follows:

Number of men out in U. S.	264,000
Loss to men in wages alone, approximately	$140,000,000
Loss to railways estimated.............	$360,000,000
	$500,000,000

This does not embrace certain losses to shippers and individuals who sustained actual or potential losses which are impossible to estimate in dollars and cents.

Aside from the direct expense to the railways in maintaining equipment under such adverse conditions of deficient forces at exorbitant rates of pay, this unusual expense automatically extended over quite a period of time following the actual cessation of hostilities.

The result of such an expensive experience, although it brought more than one company close to the shadows of financial embarrassment, was not, in the final analysis, without its valuable lessons as the records of certain items of cost before and after the strike of the shopmen will eloquently testify.

In order to derive profit from this expensive experience, attention is invited to the tabulation above of the principal direct items of cost involved on twenty railways, so distributed in the selection as to be geographically representative of the entire country, as follows:

(a) New England District........	4 railways
(b) South Eastern District..........	4 railways
(c) Southwestern District	4 railways
(d) Northwestern District	4 railways
(e) Central District	4 railways

These 20 railways with a mileage of about 96,000 miles, it will be noted are very evenly distributed over the United States. A study of the costs of locomotive maintenance both in the average amount per engine per year and in the cost per locomotive mile run in cents, serve as a good index and measure of the resourcefulness of the officers of certain railways to profit by their experience and get back to normalcy. Some have not only gotten back but are actually below the 1921 or pre-strike costs, which is indicative of that high degree of managerial ability which results in economy and efficiency in operation.

The costs for 1923, which were abnormally high, have been purposely omitted from this table, but it is proper to state that the average cost per engine on some lines ran as high and even above $11,000, while the cost per mile run on many lines was as high as 46 cents per mile. It therefore follows that those who have gotten back to 1921 figures have accomplished much more than this tabulation actually shows.

From the foregoing, including a study of the table, it must be clear that some are leading the van in efficiency and economy, while others are not only following but are a little too far in the rear, all things considered.

In the New England section it is worthy of note that both the Maine Central and Central Vermont have a lower average cost per engine per year and in cents per mile run than in 1921, while the same is also reflected in the much lowered costs per 1,000 ton miles moved. In the Southeastern group, it would appear that the Atlantic Coast Line and Central of Georgia had done much better than others, although the Southern Railway succeeded in lowering the costs per 1,000 ton miles of freight. In the Southwestern section all lines made a good showing in the costs per 1,000 ton miles of freight moved, while all but one line made wonderful strides in reduced costs per engine and repairs per mile run. The Northwestern section in many ways show better results than the last mentioned one; the St. Paul and Great Northern in particular, while the other two lines have done splendidly, if we consider all factors. In the Central District, it is interesting to note that most all the units are very low in 1924 considering the conditions of each and that the costs per 1,000 ton miles of freight moved shows a marked reduction over 1921. Many interesting and valuable lessons may be drawn from a study of these figures, particularly by one who may have been brought in touch with the actual situation itself. It is possible for the careful observer to see wherein the success of one line lies in comparison with another. In some cases, although a road may show a lesser degree of efficiency in operation than another, when all contributing factors are considered, it should be leading instead of following the procession. War certainly has its lessons from which we should all profit.

Electromotive Locomotives and Motor Cars*

By W. B. POTTER, Engineer of the Railway Department, General Electric Company

The history of developments in motive power and methods of conducting transportation has been well covered in the recent addresses of Mr. Samuel M. Vauclain before the Mid-West Power Conference, which was published in the February, 1926, issue of RAILWAY AND LOCOMOTIVE ENGINEERING.

The European engineers are showing commendable activity but seem to be dividing their efforts among a great variety of schemes. We are probably making more real progress in this country by devoting our efforts principally to the one general scheme which gives greatest promise of success. It is but comparatively few years since steam and horses were our main reliance. Electric railways, as we know them today, have been in existence but little over thirty-five years, and gasoline automobiles a little more than twenty-five years. The great and rapid increase in the number of electric railways and automobiles would not have taken place if they had not better served the purpose than other methods of transportation.

The horse could not successfully compete with these innovations either at hauling cars or on the road. Even the steam locomotive is losing some of its prestige, granting to railway electrification and motor trucks and busses the service for which it is not so well adapted, or where the requirements are beyond its capacity.

The electric street railways in their turn are now finding the motor bus to be a competitor more advantageous for certain kinds of service. The electric motor and the internal combustion engine have each in their way been the principal contributing factors toward the many changes which have taken place. Even so, we still have horses and steam locomotives—no one expects to see them entirely replaced. The horse is on the decline, while the steam locomotive is still courageously and very successfully striving to make the grade.

The union of the internal combustion engine with the electric traction motor is now seeking recognition. This combination is rapidly becoming more prominent in the field of transportation, and it has already shown that it can serve some classes of transportation better than either the engine or electric motor would be able to do independently. This motive power equipment as a whole might very properly be designated under the name of "electromotive" in the same general sense as the title of this evening's subject.

Through years of development the internal combustion engine has been brought to a degree of perfection where the reliability of its performance need be no longer in question. It requires but little auxiliary equipment and is very efficient in fuel consumption, even in engines of small size. Engines of this type, whether for gasoline or oil, have heretofore been designed principally for stationary, marine and automotive road service. Owing to limitations in weight and space when installed on a locomotive or rail car, and for the powers required, there are few engines designed for other purposes that are really applicable to rail service. The best results will be obtained by building engines for this particular purpose.

To utilize an internal combustion engine to the best advantage for transportation purposes, with its requirement of widely varying torque and speed, it is necessary to provide some means of changing the torque ratio between the engine shaft and the driving wheels. As the torque of this type of engine has definite limits, the engine would have to be of very large size unless some

* An address before the Western Railway Club, Chicago, Ill.

means is provided for augmenting the torque. For this reason some method of changeable gear reduction is in almost universal use. The mechanical transmission, with its different gear ratios, is very successful as used in the automobile, with which we are all familiar. It is doubtful whether mechanical transmission will ever be successful, however, above certain limits as to horsepower and weight to be moved. One hundred and fifty horsepower with a weight of twenty-five tons would appear to be about the upper limit, though some will doubtless disagree with this limitation.

As a substitute for mechanical transmission fluid drives have been developed in which a pump driven by the engine is provided with means for varying the stroke and so transmitting the power at variable pressure through a fluid motor. In theory it meets the requirements for smoothly providing for a wide range in torque and speed. In performance the fluid drive does not yet appear to be free from the problems of dealing with fluid at high pressure and temperature through the mechanism and pipe connections.

Compressed air drive with the engine driving an air compressor and the exhaust used to preheat the air and so operate a reciprocating air engine, has been tried and is still receiving consideration. With a large reservoir this would maintain a good load on the engine, but either as to efficiency or mechanism it is doubtful whether this method will prove altogether satisfactory.

Various schemes have been proposed for combining an oil engine with a boiler and steam engine. This with the object of obtaining higher efficiency and the additional torque for starting. While such a combination is attractive in theory, it involves so much complexity of equipment that it is not promising for general service.

In theory, as well as in practice, the success of electric drive has been thoroughly demonstrated by long experience with electric apparatus in transportation, and it is well attested by the success of gas electric cars having 200 h.p. engines which have been in successful operation for some fifteen years.

Briefly described, the electromotive equipment consists of an engine driving a direct current generator which supplies current to motors of the usual type common to electric railways. Electric reversing and series parallel switches provide for directional movement and customary motor combinations. Variation in the speed and torque of the driving wheels is smoothly accomplished throughout the entire range of simply varying the voltage of the generator. This may be done by manual control of the generator excitation or may be obtained automatically by designing the generator with a drooping characteristic so that the resulting voltage will vary inversely with the current demand. By the manual method an electric controller has to be manipulated as well as the throttle of the engine. By the automatic method the control is entirely by means of the engine throttle. A combination of the manual and automatic control is used where it is desired to utilize the engine power over a wide range of locomotive or car speed.

The space on a locomotive or motor car is so limited and the supporting floor or frame foundation is subjected to so much movement that it will be preferable in many cases, and particularly where the engine power is large, to install two or more engines, rather than one of larger size. This dual equipment has a further advantage in that it provides for running one or both engines as would be permissible in a variable service, and by so doing maintain a better load factor and lower consumption of fuel and lubricating oil. Only a few seconds are required to start the engine so there is no appreciable delay when the second engine is required. The electrical connections are such that the engines will divide their load in proportion to the fuel supply, regardless of the engine adjustment. Where it is desired to operate two locomotives or motor cars together as a unit for increased power, a control can be readily provided which will accomplish this in a manner similar to the multiple unit operation of electric cars.

The success of the oil electric locomotive has been well demonstrated by the performance of these locomotives in regular railway service. The Central of New Jersey, Baltimore & Ohio and Lehigh Valley railroads each have a 60-ton locomotive driven by a 300 h.p. Ingersoll-Rand engine, handling switching service in their yards on the water front in New York. The Long Island Railroad is operating a 100-ton locomotive driven with a dual equipment of two 300 h.p. Ingersoll-Rand engines, which is engaged in switching service in their yards adjacent to Brooklyn.

There are now under construction several more similar oil electric locomotives intended primarily for switching service, two of which will be sent to Chicago. The oil electric locomotives in operation have an excellent record, although they have not been entirely free from such minor troubles, both mechanical and electrical, as might be expected in any new development.

Two oil electric locomotives for road service have been purchased by the New York Central, one having a 750 h.p. Ingersoll-Rand engine, the other an 800 h.p. McIntosh & Seymour engine. In addition to furnishing the electrical and mechanical equipment for the above, plans have been drawn by the American Locomotive and General Electric Companies for a 1,500 h.p. locomotive, having two 750 h.p. Ingersoll-Rand engines, located beside each other within the same cab. The Baldwin Locomotive Works, as you know, has already built an oil electric locomotive equipped with 1,000 h.p. engine and Westinghouse electrical apparatus.

It appears to be the opinion of those who are operating oil electric locomotives that they will handle switching movements better than steam locomotives of equal weight on drivers, one reason for this being the even torque of the electric motor which permits a higher coefficient of adhesion than is obtained with a steam switcher. It might well be questioned whether a 300 h.p. oil electric will do the work of a steam switching locomotive capable of delivering 800 h.p. or more. The answer is in the small horse power actually required for switching. The tractive effort is high, but the speed is low. The larger powered steam switchers could maintain tractive effort at higher speed than the oil electric, but where this higher speed serves no purpose, the higher maximum tractive effort of the oil electric gives it an advantage.

The relative fuel consumption of oil electric and steam locomotives can perhaps best be given by comparing the gallons of oil with the tons of coal for a given service. The comparative records in switching indicate that twenty to twenty-five gallons of oil are equivalent to a ton of coal. With oil at five cents a gallon, the cost of fuel on this basis would balance at $1.00 to $1.25 per ton for coal. In main line service where the oil engine would show higher fuel economy because of the better load factor, the steam locomotive would also show considerably better performance in coal consumption. A rough estimate for main line service might be taken as 35 to 40 gallons of oil as equivalent to a ton of coal. On this assumption, the cost of oil would balance at $1.75 to $2.00 per ton of coal.

The fuel economy obtainable with an oil engine may be illustrated by the performance of the 300 h.p. Ingersoll-Rand engine. The fuel consumption of this engine is

given as within .43 lb. of oil per brake horsepower at full load. Including the generator losses, this means the delivery of a kilowatt hour electrical output for about 12,000 B.t.u. Those of you familiar with power practice will appreciate that this would be a high mark for the most modern steam power station.

As the oil engine does not operate continuously under full speed load, it is of more interest to know what is the fuel economy in service. During several weeks switching operation of a 60-ton locomotive with this engine under variable load which averaged about 15% load factor, the electrical output was 6.3 kw.-hr. per gallon of fuel, or about 21,500 B.t.u. per kilowatt-hour. As the average duty on the engine during this service was less than 50 h.p., it is a good illustration of the excellent performance of an oil engine under widely varying load.

The oil engine and the electrical equipment being composed of relatively small parts, easy to handle, and there being no boiler to overhaul, the maintenance of an oil electric will undoubtedly be less than that of a steam locomotive. One-half the maintenance of steam would seem to be a reasonable assumption.

The work of overhauling being less than on a steam locomotive, and considering the ease with which incidental repairs can be made, it seems reasonable to assume that the oil electric locomotive will be available for service at least 75% of the time. This is a higher availability than for steam and somewhat less than for electric locomotives.

In main line service there is no reason so far as the motive power is concerned why the run of an oil electric locomotive should be from terminal to terminal without regard to the mileage. The recent trans-continental trip of the Canadian National oil electric car is an example of what may be done though it is not likely that so long a run will very soon become accepted practice.

Although gasoline engines, as well as oil engines, have been used on locomotives, it is probable that the oil engine will be more generally used with the larger horsepowers required for locomotive service where the fuel cost becomes an appreciable item. The gas electric locomotive with its lower investment is well adapted to handle light service where the power requirement is small and the fuel expense unimportant.

The number of independent motor cars in rail service is rapidly increasing and may soon become a part of the transportation equipment on nearly every railroad. There are reported to be at present about five hundred gasoline motor cars distributed among one hundred and eighty-five railways. Included in this number are about one hundred and fifteen cars with gas electric drive in operation on thirty-one railways. The other four hundred are mostly smaller cars with mechanical transmission. The larger gas electric cars have been so successful that they may be accepted as a well established equipment for passenger transportation. For reasons previously mentioned, the electric drive has proven to be the most satisfactory and particularly so with the additional duty of frequently hauling trail cars.

The gas electric car is not a new venture into the field of transportation as some sixty or more cars of this type furnished by the General Electric Company have been in regular service during the past twelve to fifteen years. Many of these cars have covered more than 60,000 miles annually. Two old G. E. gas electric cars on the Rock Island have just been given their first general overhaul, both having run over 490,000 miles. The electrical equipment required practically no attention, major repairs being on mechanical parts and engine. A gas electric car recently furnished by the Electro-Motive Company is doing better than 400 miles a day. The operating expense of gas electric cars is usually given as 35 cents to 40 cents a car mile, including a reasonable amount of depreciation. It might be thought that this operating cost would materially increase as the cars continued in service, but the record of gas electric cars that have been running for twelve years or more is still within this cost per car mile. There are seven oil electric cars with Beardmore engines now in operation on the Canadian National Railways and one that is being equipped with an oil engine by McIntosh & Seymour for the New York Central.

The principal advantage in favor of an oil engine is the lower fuel cost, but on the other hand this type of engine has so far been considerably more expensive, and with the same degree of reliability will presumably be heavier than the gasoline engine. Oil engines can be built which compare in weight with the gasoline engine, but this is generally obtained by the use of alloy steels and a refinement of the design which materially increases the cost. The efficiency of the gasoline engine, while very good, is not equal to that of the oil engine, and roughly, for corresponding work, the quantity of fuel will be from 50% to 75% more with gasoline. At a ratio of three to one for the price per gallon of gasoline as compared with oil the relative cost of power would be about five to one in favor of oil. The oil engine is undergoing a development which may ultimately make it well suited to rail cars, and even road vehicles, but the trend is more likely to be towards using a cheaper grade of fuel in the gasoline type of engine. The use of this cheaper fuel would reduce the cost of power to something less than the before mentioned ratio of five to one.

So many of the railways are interested in highway transportation that just a word as to electric drive for busses will not be out of place. One might well ask why use electric drive for a service which is being so generally and well handled with mechanical transmission. Some of the reasons may be briefly covered by mentioning better schedule speed in frequent stop service, less number of engine revolutions to cover a given mileage, less mechanical strain on the engine and driving mechanism, and more important—a smoother acceleration, greater comfort for passengers and greater safety by reason of better control of the bus.

As evidence of progress in the art of railroad transportation, we have at least a greater number of methods from which to make a selection. We now have steam locomotives, complete electrification and electrification in the form of electromotive locomotives and cars. While for each type there is service for which it is most suitable, it is not easy to make a decision unless it is clearly indicated by the conditions. Railroad men are naturally disposed to favor the steam locomotive and with very good reason. On the other hand, the advocates of other methods of conducting transportation sometimes fail to appreciate the railroad man's point of view. It must be admitted by everyone that the steam locomotive is no longer the only means for moving a train and that we may expect it will be gradually and in part replaced by other power equipment more suitable for some particular service. This may take place because of conditions unfavorable to steam operation, but in many instances it will be because of earning a better return on the investment.

Complete electrification will reduce the number of locomotives required, provide a more powerful motive power, decrease the cost of motive power maintenance and eliminate the many incidental facilities required by steam power. Against these and many other advantages there is an initial investment so large that it must be fully justified. It is not always easy to finance a big undertaking or to convince those who provide the funds. Where it can be shown conclusively that the expenditure is warranted there

should be no hesitation about complete electrification.

Unit electrification with electromotive locomotives and motor cars is really a form of electrification with many of its attractive features. It has the advantage of calling for small initial investment and it is not limited as to location, neither does it require any overhead structure and wires. It is not expected to accomplish all that can be done with complete electrification, but it nevertheless has a large field of usefulness.

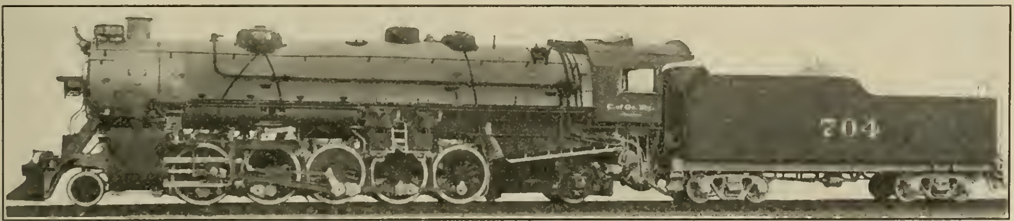
The oil electric locomotives now in operation were designed primarily for switching service, but there is no doubt that more powerful locomotives will be equally successful for main line traffic. In any class of service where coal is expensive, smoke an objection, or water difficult to obtain, the use of oil electric locomotives undoubtedly will be extended.

The substitution of gas electric cars for light passenger traffic will appreciably reduce the cost of handling such service by steam locomotives. The difference in operating cost and the stimulus to travel by giving a cleaner and better class of service will bring in a larger net return to the railroad and may even change the balance sheet from a deficit into attractive profit.

"What effect the general use of electromotive equipments will have upon steam railroad electrification," is a question frequently asked. The effect is more likely to be favorable than otherwise. It will have no particular influence where complete electrification is a necessary or obviously the proper procedure. It may appear to delay some prospective electrification where there is a preference for electromotive power for the initial equipment. Should the conditions really be favorable to complete electrification, it is more likely that it will be undertaken by this proceeding, than that the entire expenditure would be incurred without experience with other than steam operation. The introduction of electromotive locomotives and cars will certainly acquaint the railroads with electric traction equipment. Favorable experience with this class of electrical apparatus will do more to educate railroad men in what can be done by electrification than all the talk and publications which can be presented. Whenever more power is wanted the power companies stand ready to supply the need for complete electrification—the power delivered through an overhead wire will then serve in the place of the electromotive power plant. The reputation of the electric motor for traction purposes will have already been established among the railroads and the way made easier for its more general use.

2-10-2 Type Locomotives for the Central of Georgia Ry.

The marked increase in traffic which has recently taken place on the railroads of the South is taxing existing facilities severely and necessitating the use of the heaviest motive power permitted by track and bridge conditions. The Central of George is no exception in this respect; and is steadily improving its property with a view of maintaining the high standard of service for which this road is noted.



Santa Fe Type Locomotive of the Central of Georgia Railway Built by The Baldwin Locomotive Works

The latest addition to the motive power equipment is a group of ten locomotives of the 2-10-2 type, recently completed by The Baldwin Locomotive Works. These locomotives exert a tractive force of 73,830 pounds and are designed to traverse curves of 18 degrees; and many of their principal dimensions accord with those of the heavy standard 2-10-2 type locomotives built for the United States Railroad Administration. In the design of the details, however, the new locomotives show many differences.

The heaviest locomotives previously built for the Central of Georgia by The Baldwin Locomotive Works were of the Mikado (2-8-2) type and were placed in service early in 1925. A comparison of their principal dimensions with those of the new 2-10-2 type locomotives, is as follows:

Type	Cylinders	Drivers diam.	Steam pressure	Grate area	Water heating surface	Super-heating surface	Weight on Drivers	Weight total Engine	Tractive force
2-8-2	27"x30"	63"	185	70.5	4,094	905	226,760	298,090	54,500
2-10-2	30"x32"	63"	190	88.3	5,233	1,285	309,220	401,480	73,830

This represents an increase in tractive force of 35 per cent, with approximately equivalent increases in weight, heating surface, and grate area.

The 2-10-2 type has a conical boiler, 100 inches in diameter at the largest course. The fire-box has a 5-foot combustion chamber, and it contains two thermic syphons and three arch tubes. A Duplex stoker is applied.

These locomotives have lateral motion boxes on the front pair of drivers, and plain tires on the middle (main) pair. The leading truck is of the constant resistance type, while a Delta trailing truck is used in combination with the Commonwealth rear frame cradle. The main frames are 6 inches wide with double front rails, the top rails being bolted and keyed to the main sections. Special attention has been given to providing ample support for

the boiler barrel on the frames. The waist sheet and guide bearer T-irons are not attached to the boiler, but bear against external liners which are riveted to the shell.

The piston heads are of rolled steel with gun iron bull and packing rings, and the piston rods are of carbon vanadium steel. The latter material is also used for the main crank pins and the main and side rods. The back ends of the main rods, and the side rod stubs on the main pins, are fitted with floating bushings. A force feed lubricator, with six feeds, is applied, and is operated from one of the link trunnions. One feed runs to each cylinder and steam chest, one to the two duplex air-pumps and one to the stoker engine.

The valve gear is of the Walschaerts type controlled by a power reverse mechanism. On one locomotive the eccentric cranks are set to give a variable lead, amounting to 1/16-inch in full gear forward, ¼-inch in mid gear and 7/16-inch in full gear backward. On the remaining locomotives, the motion is designed to give a constant lead of 3/16-inch.

These locomotives are equipped with flange oilers on the first and second pairs of driving wheels, and also with pipes for washing sand from the rails back of the rear drivers.

The tenders have Commonwealth cast steel frames, and water bottom tanks of 12,000 gallons capacity. The coal capacity is 16 tons.

Further particulars are given in the table of dimensions.

Type	2—10—2
Gauge	4 ft. 8½ in.
Cylinders (4)	30 x 32
Valves, piston diam.	15 in.
Boiler:	
Type	Conical
Diameter	88 in.
Working pressure	190 lb.
Fuel	Soft Coal
Firebox:	
Material	Steel
Staying	Radial
Length	132⅛ in.
Width	96¼ in.
Depth, front	94½ in.
Depth, back	70½ in.
Tubes:	
Diameter	5½ in.—2¼ in.
Number	50—271
Length	20 ft. 6 in.
Heating Surface:	
Firebox	268 sq. ft.
Combustion chamber	121 sq. ft.
Tubes	4,729 sq. ft.
Firebrick tubes	27 sq. ft.
Thermic syphons	88 sq. ft.
Total	5,233 sq. ft.
Superheater	1,285 sq. ft.
Grate area	88.3 sq. ft.
Driving Wheels:	
Diameter, outside	63 in.
Diameter, center	56 in.
Journals, main	12½ in. by 13 in.
Journals, others	10 in by 13 in.
Engine Truck Wheels:	
Diameter, front	33 in.
Journals	6½ in. by 12 in.
Diameter, back	44 in.
Journals	9 in. by 14 in.
Wheel Base:	
Driving	22 ft. 4 in.
Rigid	22 ft. 4 in.
Total engine	42 ft. 6 in.
Total engine and tender	82 ft. 5 in.
Weight in Working Order:	
On driving wheels	309,220 lb.
On truck, front	30,270 lb.
On truck, back	61,990 lb.
Total engine	401,480 lb.
Total engine and tender	609,500 lb.
Tender	
Wheels, number	8 in.
Wheels, diameter	33 in.
Journals	6 in. by 11 in.
Tank Capacity:	
Water	12,000 U. S. gal.
Fuel	16 ton
Tractive force	73,830 lb.
Service	Freight

Snap Shots

By THE WANDERER

A good many years ago, when car decorations were of the rather flamboyant type and before they had assumed the subdued tone that we now consider good taste, someone described the interior of a Pullman sleeping car as being a gingerbread example of barbaric splendor. But such things are mostly of the past, especially the cheap examples. However, profuseness will sometimes burst upon us.

There is an old Latin proverb to the effect that there can be no dispute about a matter of taste. And as what follows is mostly as to taste with a slight touch of the economic added, it should be read, if read at all, with that as an understanding.

I went into the dining car of a somewhat widely advertised train de luxe the other evening and thought, at first, that I had dropped back into the period of gingerbread barbarism. There seemed to be a mixture of white and black and silver, staring and swearing at each other. But upon closer survey and a reference to the menu I found that I was in a car where the clerestory and the side walls were formed along the lines of a colonial architecture; that the electric lights of the monitor were held in silver sunbursts and that the chairs were modeled after some of the old colonial designs. Then there was a sideboard modeled on the Sheraton lines and all supposed to be very magnificent. But somehow the colonial architecture did not seem to lend itself very well to the side walls of a car, and the elaborate sideboard seemed rather out of keeping with the place it occupied, so that the appearance of the whole was not particularly pleasing to my eye, nor did it seem appropriate.

But it had one great merit that must appeal to the nouveau riche. It was all very expensive. The total cost of the car, I was told, was $58,000.00 and the chairs alone cost $110.00 apiece, while the silver sunbursts that held the overhead lamps, were of a special design that would not be duplicated and cost $120.00 each. What the imitation Sheraton sideboard cost, I did not ask for fear of being quite overcome by the magnificence with which I was surrounded.

That was all very fine, but—and that BUT should be printed in capital letters—when I asked how much the dining car service cost the road, in other words, what the road was losing on the service, I was told that it amounted to about $1,000.00 a day. Perhaps that might please the *nouveau riche* also, if it did not appear to be a particularly attractive item to the stockholders. If we take the cost of an average dining car at $28,000.00 we have an overhead addition of the interest on $30,000.00 to be charged against this car, or about $1,800.00 a year. I wonder if it was the expectation of the management to add $1,800.00 to the net revenues of a single car by this attempt at a splendor that, in the opinion of some passengers at least, was not achieved.

The riding of the car was no easier, the food was no better, and the expensive chairs were no more comfortable than that of less pretentious cars of plain interior and of no special period. In fact the portions served in the table d'hote dinner were so small that one man of moder-

ate appetite, at least, would have left the car hungry had he not added a supplement from the à la carte menu.

Would not the car and the menu and the luxury lead me to prefer that route to any other? When the car steward asked me that question, I told him "No."

Am I alone, or are there some or many others like me?

I doubt if the dining car service attracts any business to the railroad. It may, I don't know. But in all of my somewhat extensive experience, I have yet to hear any man say that he traveled by any particular route because of its dining car service. Comparisons? Yes and a plenty. Some services are much better than others, but not enough to act as a drawing card. And this, I take it, because most people avoid patronizing the dining car as far as possible.

So reverting back to the car in question. It was an interesting example of—I was about to say, "freak"—car designing, and some may consider it beautiful, but as a business proposition, I hardly think that even those who ordered and designed it, would consider it a good one.

It has always seemed strange to me that when a present justice of the Supreme Court came out with the rather spectacular statement, a few years ago, to the effect that, by proper management, the railroads could save $1,000,000 a day, and when amid the storm of protest and ridicule it aroused, he did not reply to the repeated questions of "How," by saying: "Well you can make a good start towards it by cutting out your unprofitable dining car service."

When road after road reports a deficit running from $300,000 to close to $1,000,000 a year, it does seem, to use a popular phrase, "something ought to be done about it." But who will bell the cat?

A contributor to a popular magazine recently wrote, in regard to the costumes of men: "Are we permitted even in the direst of dog days to take off our suffocating, sweat-box coats and go about sensibly in spotless sport shirts and belted tennis trousers?

"Answer is, thunderingly and disgustedly, No!"

To paraphrase:

"Are we permitted even in the direst stress of financial embarrassment to take off, from the menu, the multiplicity of useless luxuries and go about serving simple, well-cooked and wholesome meals?

"Answer is thunderingly and horrifiedly, No!"

If we ask, why? We are told that the other fellow won't do it, just as he won't go in his shirt sleeves. And yet there is an almost unanimity of opinion among the dining car stewards that if such a course were to be adopted, the service might be put on a paying basis. As one of them said to me:

"If I were to serve such a dinner as you describe (I had told him of the simple and satisfactory menu of a first-class country hotel), I could greatly reduce my crew. I now carry three cooks and eight waiters. I could dispense with two cooks and four waiters because such a meal could be much more expeditiously served."

Well that would mean six mouths to feed and six men to pay instead of twelve. Something to start on, anyway.

Of course there would be a howl and a cry, but would it be any worse than it is now? Well cooked food would at least cure the chronic complaints of under done meats and unpalatable vegetables. And the stewards assure me that they think such a service would be quite as satisfactory as the present one.

Lord Dundreary once remarked that, "there are some things no fellah evah can find out," and why the railroads, with the almost ruinous dining car deficits staring them in the face year after year, cannot come to an agreement to stop it, seems to be one of those things that the fellah on the outside can't evah find out.

And the difficulty of finding out is not lessened by the construction of cars with a seemingly reckless disregard of cost, in the face of colossal losses. I might as well give it up, but the subject is so attractive that I can give no guarantee that I will not be drawn back to it again.

Drawing rooms at outlying points are not very common, yet the master mechanic or shop foreman has frequent occasion to make or have a drawing made. I saw a little drawing room the other day that for coziness and convenience beat anything I ever ran across. When there is a big shop and a corps of draughtsmen the drawing room is usually all that can be desired, but when a drawing board is set up at outlying points, for occasional use or where one man can do the work he is usually tucked away anywhere and left like the employes at Tellson's, to grow old; and that anywhere is not apt to be the best lighted place in the world. However, that is neither here nor there. This, my model drawing room, was an old steamboat pilot house with windows all around it, with curtains for toning down the glare. It was set up on the roof and was the coolest place about the premises in summer and as cosy a place to work in as you ever saw.

I don't suppose that many of my readers have old pilot-houses in their back yards or that they can be found lying around in the cinder pits, but an old cab will run them a close second, and one of these can be utilized. Therefore, when you have decided that there is any drawing to be done, don't wait until you hire a regular draughtsman, for you will probably do some yourself first, but just appropriate an old cab or build a cupola on a roof and use it exclusively for a drawing room for it will be light and clean if you have a mind to keep it so. But, don't think that you can get any satisfaction out of a dark corner of a roundhouse cubby hole.

Test Draft Gears for Greater Safety

With a view to further increasing public safety and comfort while traveling and reducing loss and damage both to freight shipments and to railway equipment, a thorough study of draft gears used on both freight and passenger cars is to be made by the American Railway Association to determine what improvements can be made in the types already in use on the railroads of this country.

The Association has authorized an appropriation for the purpose of building a specially constructed machine for testing draft gears in order to ascertain their absorption of recoil and endurance. From the information obtained, the Association plans to prepare suitable specifications under which the railroads may purchase draft gears that are known to meet the prescribed standards of efficiency.

Novel Testing Machine

The machine for testing draft gears, which is now being constructed, will be the largest that has ever been used for the purpose. A novel feature of the machine will be two falling weights, the larger one weighing 27,000 pounds and the smaller one 9,000 pounds, the latter being the weight most frequently used heretofore in similar test machines. The machine will be driven electrically, the control equipment being so designed that operation may be manually or automatically controlled. It will be equipped with various devices to record the action of draft gears under various tests.

The machine when completed will be installed by the American Railway Association at one of the leading en-

gineering universities, probably Purdue University at Lafayette, Indiana, where the Association has already installed special equipment and is conducting a series of tests of air brakes with a view of determining what improvements can be made in the present air brake systems now in use.

New Locomotive Inspection Rules

Pursuant to the requirements for rules and instructions for the inspecting and testing of locomotives propelled by other than steam power, in accordance with the act of February 17, 1911, amended March 4, 1915, June 26, 1918, and June 7, 1924, the Interstate Commerce Commission has compiled, published, and issued a set of rules and instructions for inspecting and testing all locomotives other than steam, to become effective July 1, 1926, except as otherwise specified in the rules.

These follow very closely the general arrangement of the rules and instructions now in use for the inspection of steam locomotives, and in order that there may be no misunderstanding as to the application of the new rules, definitions are given as to the equipment they cover. A locomotive is defined as a self-propelled unit of equipment designed solely for moving other equipment. A motor car is defined as a self-propelled unit of equipment designed to carry freight or passenger traffic, and is not to be considered as a locomotive.

These rules and instructions were formulated at conferences participated in by representatives of the carriers, representatives of the employes, and the chief and assistant chief inspectors of the Interstate Commerce Commission. They were approved by order of Interstate Commerce Commission December 14, 1925, and include rules number 200 to 261 inclusive, and 300 to 337 inclusive, together with cuts, tables, drawings and forms of the usual type required for the inspection of steam locomotives.

One section is general and outlines the scope and application of the rules and instructions. In this section it is stated a locomotive, as constructed by these rules, may consist of one or more units. The term "units" as used in these rules and instructions meaning the least number of wheel bases, together with superstructures, capable of independent propulsion, but not necessarily equipped with an independent control. The rules also provide that each locomotive be stenciled with the letter "F" on each side near the front end to designate the front or head end of the locomotive. Each unit of the locomotive must be numbered also on each side. As is the case with steam locomotives, each locomotive must be inspected after each trip or day's work, and forms are illustrated on which reports of these inspections are to be made.

New Magneto Drive for Electric Locomotive Tachometer

A new form of magneto drive has been recently developed by the Electric Tachometer Company of Philadelphia in conjunction with the Westinghouse Electric and Manufacturing Company for the application of electric speed indicators to locomotives. This new drive permits the installation of an electric tachometer outfit in a few minutes time, and eliminates the use of special gears, pulleys or belts.

The outstanding feature of the new design is the method of driving the magneto from the locomotive wheel and the fact that this speed indicator operates independent of all other apparatus whereas previous designs were essentially attachments for use with train control. It has formerly been necessary to use special gears or a belt for this type of drive. The new drive eliminates the use of special attachments and also eliminates the possibility of lost motion in a slipping belt. It can be attached to any locomotive by use of ordinary hand tools. No "extras" are required for the installation. The outfit is complete in itself.

The magneto is mounted (with shaft vertical) on the framework above or adjacent to one of the leading wheels on the locomotive. A small gear box is attached to the end of the locomotive axle, outside of the wheel. Only three small tapped holes in the axle are necessary for mounting. A short length of flexible shaft connects the gear box to the magneto. The gear box contains a pair of bevel gears. One of these is attached to the locomotive axle. The other is mounted in a housing which is free to revolve around the first bevel gear as a center. The flexible shaft is attached to the second bevel gear and pre-

Magneto Drive for Electric Locomotive Tachometer

vents actual rotation of the housing, although a small amount of motion is permissible. In action, the housing remains stationary and the gears revolve, transmitting motion through an angle of ninety degrees to the flexible shaft and magneto. This construction reduces the transmission problem to its simplest form and takes care of all movements of the locomotive wheels with respect to the locomotive frame. It allows the magneto to be rigidly mounted, as its heavy construction requires, and at the same time provides a positive drive which is independent of various wheel positions.

The development of this drive is a decided forward step in the design of locomotive speed indicators. It solves at the same time the problems of easy installation, interchangeability, and independent operation. It eliminates the necessity of an engineer guessing as to whether or not he is going at the speed necessary to keep on schedule. In addition to this it also has been a means of saving fuel due to the fact that the enginemen can judge and regulate the speed of an engine when going up a grade and throw open the throttle soon enough so that it will be unnecessary for any extra effort to be extended to make the grade.

Notes on Domestic Railroads

Locomotives

The Pennsylvania Railroad has placed an order for 175 Mountain type locomotives with the Baldwin Locomotive Works and has also ordered 25 of the same type from the Lima Locomotive Works.

The Alton & Southern Railroad has placed an order with the American Locomotive Company for one Mikado type locomotive

This locomotive will have 25 in. by 30 in. cylinder and a total weight in working order of 275,000 lb.

The Kentucky & Indiana Terminal Railroad is inquiring for 3 six-wheel and 8 eight-wheel switching type locomotives.

The Boston & Maine Railroad is inquiring for one to 5 Diesel electric locomotives.

The Georgia Florida & Alabama Railway has placed an order for 2 Mikado type locomotives with the Baldwin Locomotive Works.

The Great Northern Railway is inquiring for one oil-electric locomotive.

The Union Railroad is inquiring for 10 six-wheel switching type locomotives.

The New York Central Rialroad is contemplating the purchase of 100 locomotives.

The Detroit & Toledo Shore Line Railroad is inquiring for 3 six-wheel switching type locomotives and 3 Mikado type locomotives.

The Long Island Railroad is building 7 switcher type electric locomotives in the Altoona shops of the Pennsylvania Railroad.

The Reading Company is inquiring for 25 locomotives.

The Delaware Lackawanna & Western Railroad is inquiring for 10 Mountain type and 15 Mikado type locomotives.

The Longview Portland & Northern Railway has placed an order for 2 Mikado type locomotives with American Locomotive Company.

The Akron Canton & Youngstown Railway has placed an order for 2 switching type locomotives with the Lima Locomotive Works.

The Southern Railway has placed an order for 16 heavy Mikado type, 23 Pacific type, 10 Consolidation type, and 5 light Mikado type locomotives from the American Locomotive Company.

The Tennessee Coal, Iron & Railroad Company has placed an order for one six-wheel switching type locomotive with the American Locomotive Company.

The Southern Railway has placed an order for 22, eight-wheel switchers with the Lima Locomotive Works, and also 7 with the Baldwin Locomotive Works.

The Chicago, Rock Island & Pacific Railway has placed an order for 10 Mikado type and 5 Mountain type locomotives with the American Locomotive Company.

The Standard Slag Company has placed an order for one, 4-wheel tank type locomotive with the American Locomotive Company.

The Reading Company has ordered 5 Pacific type locomotives from the Baldwin Locomotives Works, and one, 60-ton oil-electric with the American Locomotive Company.

The Wabash Railway is inquiring for 30 locomotives.

The Argentine State Railways will open bids May 3, for 20 Santa Fe type locomotives.

The Brazilian Portland Cement Company has ordered one, 2-4-2 tank type locomotive from the American Locomotive Company.

The U. S. Gypsum Company has ordered one, 6-wheel switching locomotive from the Baldwin Locomotive Works.

The Egyptian State Railways are inquiring for 40, 2-6-2 saddle tank switching type locomotives.

The Mogyana Railway of Brazil has ordered 8 Mikado type locomotives, and 2 Pacific type locomotives from the American Locomotive Company.

Passenger Cars

The Pennsylvania Railroad has placed an order for 2 additional combination passenger baggage gas electric cars with the J. G. Brill Company, Philadelphia, Pa.

The Chicago & North Western Railway has placed an order for 2 power units for installation in one baggage-passenger double end car with the Railway Motors Corporation.

The Chicago Rock Island & Pacific Railway has ordered 5 baggage cars from the American Car & Foundry Company.

The Pennsylvania Railroad will build 24 diners in its own shops

The Alton Transportation Company, a subsidiary of the Chicago Alton Railroad has placed an order for 2 gasoline electric driven buses with the Versare Corporation of Buffalo.

The Central of Georgia Railway has placed an order for 6 coaches with the Pullman Car & Mfg. Corporation, and 5 baggage cars with the American Car & Foundry Company.

The Richmond, Fredericksburg & Potomac Railroad has placed an order for 4 coaches with the Bethlehem Shipbuilding Company, and 6 express cars with the American Car & Foundry Company.

The Pennsylvania Railroad is inquiring for 125 baggage-express cars, 74 coaches, 7 passenger-baggage coaches, 8 cafe coaches, 24 dining cars and 20 electric coaches.

The Southern Pacific Company has placed an order for 6 combination baggage postal cars with the Standard Steel Car Company.

The New York, Westchester & Boston Railway has placed an order for 10 motor passenger cars with the Pressed Steel Car Company.

The Southern Railway is building 25 refrigerator passenger service cars in their own shops.

The New York Central Railroad is inquiring for 10 electric motor car bodies.

The Illinois Central Railroad has placed an order for 3 diners with the Pullman Car & Mfg. Company.

The Reading Company is inquiring for 50 passenger cars.

The Nashville, Chattanooga & St. Louis Railway has placed an order for 4 steel baggage cars with the American Car & Foundry Company.

The Southern Pacific Company has placed an order for 10 coaches and 28 baggage cars with the Pullman Car & Mfg. Corporation.

The Chicago & Northwestern Railway has placed an order for repairs to 10 baggage cars with the American Car & Foundry Company.

The Chicago, Springfield & St. Louis Railway has placed an order for one combination baggage and mail gasoline motor car, one passenger trailer car and one combination baggage and passenger gasoline motor car from the J. G. Brill Company, Philadelphia, Pa.

The Erie Railroad has placed an order for 124 steel coaches with the Standard Steel Car Company.

Freight Cars

The Northern Pacific Railway has placed an order for 500, 50-ton automobile box cars with the Pressed Steel Car Company, and 500, 50-ton automobile box cars with the Standard Steel Car Company.

The Central Vermont Railway is inquiring for 200 single sheathed box cars with 40-ton capacity.

The Standard Steel Car Company has ordered 3 tank cars of 10,000 gal. capacity from the Standard Tank Car Company.

The Henry Bower Chemical Company has ordered one tank car of 10,000 gal. capacity from the Standard Tank Car Company.

The Damascus Manufacturing Company has placed an order for one triple compartment tank car with the Standard Tank Car Company.

The Anglo Chilean Consolidated Nitrate Company has placed an order for 62 Nitrate cars with the Koppel Industrial Car Company.

The Youngstown Sheet & Tube Company is inquiring for 20 gondola cars of 70-ton capacity.

The Glen Nina Tank Line, Buffalo, New York, has ordered 3 triple compartment tank cars of 6,000 gal. capacity from the Standard Tank Car Company.

The Central Railroad of New Jersey is inquiring for 100, 70-ton mill type gondolas; 1,000 steel frame double sheathed 50-ton box cars; 1,000 steel frame single sheathed 50-ton box cars; and 1,000 A. R. A. steel sheathed 50-ton box cars.

The Southern Pacific Company has placed an order for 1,100 box cars with the Pullman Car & Mfg. Corporation, and 500 gondola cars with the Pressed Steel Car Company.

The Colorado & Southern Railway has placed an order for 100 Ballast cars with the Rodger Ballast Car Company.

The Northern Pacific Railway has placed an order for 220 underframes from the Standard Steel Car Company.

The Pennsylvania Railroad is inquiring for 2,000 steel automobile cars.

The Florida, East Coast Railway has placed an order for 40 caboose cars with the Mt. Vernon Car Mfg. Company.

The Southern Railway has placed an order for 2,250 freight cars as follows: 1,000 box cars with the Mt. Vernon Car & Mfg. Company; 1,000 hopper cars with the Tennessee Coal, Iron & Railroad Company, and 250 ballast cars with the General American Car Company.

The Illinois Central Railroad has placed an order for 200 automobile furniture cars with the Pullman Car & Mfg. Corporation.

The North American Car Company is inquiring for 500, 8,000 gallon tank cars.

The Delaware, Lackawanna & Western Railroad has placed an order for 40 milk cars with the Standard Steel Car Company.

The Pere Marquette Railway is inquiring for 10 air dump cars.

The Baltimore & Ohio Railroad is inquiring for 16 air dump cars.

The Bloedel-Donovan Lumber Mill has placed an order for 12 steel logging cars with the Pacific Car & Foundry Company.

The Angolo-Chilean Consolidated Nitrate Company is inquiring for 120, 44-ton gondola cars.

The Chicago, Burlington & Quincy Railroad has ordered 100 ballast cars from the Rodger Ballast Car Company.

The Brazilian Portland Cement Company has ordered 10 dump cars from the Magor Car Corporation.

The Southern Railway has placed an order for 500 box cars with the Mt. Vernon Car Mfg. Company. The company will also rebuild 2,100 gondolas, 100 caboose cars and 500 flat cars in its own shops.

The Canadian National Railways is inquiring for 40 tank cars and 50 express refrigerator cars.

The Missouri Pacific Railroad has placed an order for 600 box car bodies with the Pennsylvania Tank Car Company.

The Nashville, Chattanooga & St. Louis Railway has placed an order for 125, 55-ton steel hopper cars and 75, 50-ton steel underframe flat cars with the American Car & Foundry Company. The company has also placed an order for 100, 50-ton steel selective ballast cars with the Rodger Ballast Car Company.

The New York Rapid Transit Company is inquiring for 11 freight cars.

The Imperial Refining Company, Tulsa, Okla., has placed an order for 100, 8,000 gallon tank cars with the Pennsylvania Car Company.

The Chicago & Northwestern Railway has placed an order for 250 ballast cars with the American Car & Foundry Company and 250 steel underframes with the Western Steel Car Company.

The St. Louis-San Francisco Railway will rebuild 750 flat bottom gondola cars at its yards in Memphis, Tenn.

The General Equipment Company has placed an order for 50 gondola cars with the American Car & Foundry Company.

Building and Structures

The Reading Company will build new classification yards with locomotive repair and shop facilities at Reynolds near Mahoning City, Pa., to cost approximately $1,000,000 with equipment.

The Yazoo & Mississippi Valley Railroad has acquired a site at Vicksburg, Miss., on which it plans to construct additional shop and yard facilities.

The Wabash Railway plans to build a car repair shop at Detroit, Mich., to cost approximately $100,000.

The New York, New Haven & Hartford Railroad is building an engine house at Cedar Hill, New Haven, Conn., to cost approximately $35,000. The building will be of brick and steel, 255 by 300 ft.

The Gulf, Colorado & Santa Fe has awarded a contract for the construction of shop building at Cleburne, Texas, to cost approximately $205,000.

The Chicago Burlington & Quincy Railroad plan the construction of an extension to the reclamation plant of Eola, Ill.

The Cleveland, Cincinnati, Chicago & St. Louis Railway. Plans are being prepared for the construction of an engine terminal at Riverside Yard, Cincinnati, Ohio, to cost approximately $3,000,000. The plans include the construction of a roundhouse and shops and other facilities.

Building and Structures

The Pennsylvania Railroad has placed a steel contract with the American Bridge Company for shop additions at Olean, New York.

The Chicago, Burlington & Quincy Railroad is reported to be considering the erection of a new enginehouse with repair facilities at Burwell, Nebr.

The Boston & Maine Railroad is planning a coal plant at Boston, Mass., to cost approximately $500,000.

The Wabash Railway is planning to construct a car repair shop at Oakwood, Mich., to cost approximately $100,000.

The Kansas City Southern Railway plans to erect a seven-stall addition to its enginehouse at Heavener, Okla., to cost approximately $65,000.

The Chicago, Milwaukee & St. Paul Railway is planning reconstruction of its enginehouse and shop at Channing, Mich., which were recently destroyed by fire.

The Central Vermont Railway has placed a contract with the Roberts & Schaefer Company for a junior "N & W" type cinder plant; electrically operated, for its yards at New London, Conn.

The Chicago, Burlington & Quincy Railroad plans to enlarge its enginehouse at Omaha, Nebr.

The Illinois Central Railroad has placed a contract with J. E. Nelson & Son, Chicago, for the erection of machine shops at Paducah, Ky., also for other storage buildings with Ellington Miller Company, Chicago.

The Baltimore & Ohio Railroad has purchased an automatic electric coaling station hoist for modernizing one of its old coaling plant at Morgantown, W. Va., from the Roberts & Schaefer Company, Chicago.

The Maine Central Railroad plans to rebuild its enginehouse at Bangor, Maine, which was recently destroyed by fire.

The Michigan Central Railroad has placed a contract with the W. E. Wood Company, Detroit, Mich., for the erection of an office building at Detroit, Mich.

Te locomotive shop, enginehouse, machine shops, blacksmith shops and all of machinery of the New York, Chicago & St. Louis Railroad at Frankfort, Ind., were damaged by fire recently.

The Chicago & Northwestern Railway plans to build an enginehouse at Jewell, Iowa, to cost approximately $25,000.

The Illinois Central Railroad is drawing plans for a repair shop to be built at Burnside, Ill., to cost approximately $500,000.

The Baltimore & Ohio Railroad plans alterations and additions to its locomotive and car repair shops at Cumberland, Md., to cost approximately $100,000.

The Great Northern Railway has announced the construction of a gravel washing plant at Reiter, Wash., to cost $150,000. Huge crushers, electrically operated, will be used. Gravel will be taken from pits to the crusher over a narrow gauge railroad using gasoline propelled locomotives. A Bucyrus shovel, operated by a Diesel engine, will be used in loading the cars.

The Peoria & Pekin Union Railway has placed contract for a 500-ton capacity three-track, simplex automatic electric roller skip type locomotive coaling and sanding plant at Peoria, Ill., with the Robert & Schaefer Company, also two standard "N & W" type electric cinder plants with selective control with the same company.

The Boston & Albany Railroad has installed an 85-foot turntable at Athol, Mass., to accommodate a larger locomotive.

Items of Personal Interest

G. E. Sisco has been appointed assistant master mechanic of the Fort Wayne division of the Pennsylvania Railroad, with headquarters at Fort Wayne, Ind.

T. J. Leach, master mechanic of the Cleveland and Pittsburgh division of the Pennsylvania Railroad, has been appointed master mechanic of the Middle division, to succeed **C. J. Richers.**

W. P. Petty has been appointed assistant superintendent of the St. Louis terminal division of the Missouri Pacific Railroad, with jurisdiction over the operation of the Carondelet yard.

W. P. Bruce, general manager of the Nashville, Chattanooga & St. Louis Railway, with headquarters at Nashville, Tenn., has been promoted to vice-president and general manager, with the same headquarters.

R. E. Laidlaw has been appointed superintendent of the Detroit division and passenger terminals of the Michigan Central Railroad, with headquarters at Detroit, succeeding **M. T. Wright,** who is on leave of absence on account of ill health.

W. M. Thurber, superintendent of the Dubuque division of the Chicago, Milwaukee & St. Paul Railway, with headquarters at Dubuque, Iowa, has been transferred to the Illinois division, with headquarters at Savanna, Ill., succeeding **C. F. Urbett.**

James B. Hill has been elected president of the Nashville, Chattanooga & St. Louis Railway, to succeed **Whitefoord R. Cole.** Mr. Hill was formerly assistant to the president.

W. H. Guild has been appointed superintendent of the second division of the Union Pacific Railroad, with headquarters at Portland, Oregon, succeeding **W. Bollons,** who has retired.

A. S. Ingalls has been appointed vice-president of the New York Central Railroad, with headquarters at Cleveland. Mr. Ingalls was formerly general manager of lines west of Buffalo.

J. H. Reisse has been appointed mechanical assistant to the vice-president of the Chicago, Burlington & Quincy Railroad, with headquarters at Chicago, Ill. **Mr. Reisse** was formerly mechanical inspector.

George H. Crosby, assistant to the vice-president of the Chicago, Burlington & Quincy Railroad, retired after more than fifty years of service with that company.

L. R. Christy has been appointed master car builder of the Missouri Pacific Railroad, with headquarters at Houston, Texas. Mr. Christy was formerly general car inspector, with headquarters at St. Louis, Mo.

C. B. Strohm, superintendent of transportation of the Atchison, Topeka & Santa Fe Railway, with headquarters at Chicago, has been granted a leave of absence on account of illness. **H. R. Lake,** superintendent of the Panhandle division, with headquarters at Wellington, Kan., has been appointed acting superintendent of transportation, succeeding Mr. Strohm.

J. S. Ford has been appointed master mechanic of the Galesburg division of the Chicago, Burlington & Quincy Railroad, with headquarters at Galesburg, Ill.

W. W. Weiss has been appointed superintendent of the Toledo division of the Wheeling & Lake Erie and the Lorain & West Virginia Railway, with headquarters at Toledo, Ohio, succeeding **R. F. Smith.**

R. C. Morse, Jr., general superintendent of transportation, Western region, with headquarters at Chicago, has been made general superintendent at Buffalo, N. Y., **F .D. Davis,** acting general superintendent of the New Jersey division, succeeds Mr. Morse.

L. A. Richardson, superintendent motive power, Rock Island Lines, at Des Moines, Iowa, has been appointed general superintendent motive power with headquarters in Chicago, reporting to L. C. Fritch, vice-president in charge of operation, effective April 1. Mr. Richardson succeeds **W. J. Tollerton,** deceased.

Mr. Richardson first entered railway service in 1884, as machinist apprentice on the Union Pacific Railway at St Joseph, Mo., later serving as roundhouse foreman and general foreman. He came to the Rock Island in 1906 from the Oregon Short Line as master mechanic at Trenton, Mo.; transferred to Chicago in 1910; was made mechanical superintendent in 1913 at El Reno, Okla., and transferred to Des Moines, Iowa, in 1916, where he has been located until the present appointment. Mr. Richardson was born at Bucklin, Mo., in 1868.

Supply Trade Notes

H. C. Osman, sales manager of the **Nugent Steel Castings Company,** Chicago, Ill., has been elected secretary of the company. He will continue to have charge of the sales for the company. **C. A. MacDonald,** formerly secretary, has been elected treasurer.

P. E. Floyd has been appointed by the **Ludlum Steel Company,** Watervliet, New York, as manager of sales in charge of the r Chicago office and warehouse. He succeeds **Mr. Edwards,** who has been transferred to Southern territory, with headquarters at Houston, Texas. The Ludlum Steel Company manufacture a very extensive line of tool, rustless and non-corrosive steels.

The Chicago Steel Car Company, of Harvey, Ill., has been incorporated with $100,000 capital, to manufacture railroad cars, by **F. H. Uriell, V. M. Hencher** and **Arthur Fisher.**

T. W. Bennett, service engineer for the **Locomotive Stoker Company,** Pittsburgh, Pa., is in Australia to supervise the installation and operation of duplex stokers on the ten new Mountain type locomotives built according to American practice by **Sir W. G. Armstrong, Whitworth Company,** in England, which will soon go into service on lines of the South Australian Government Railway.

Knowles Pittman, formerly sales manager of the **Nugent Steel Casting Company,** has been appointed sales manager, **Burnside Steel Foundry Company,** Chicago, Ill.

E. M. Ivens, formerly representative of the **Ingersoll-Rand Company,** with headquarters at New Orleans, La., has been appointed special agent of the **Chicago Pneumatic Tool Company,** with headquarters at Chicago, Ill.

Frank H. Colladay has resigned as New York manager of sales of the **Trumbull Steel Company,** and has been appointed district sales manager of the **Braeburn Alloy Steel Corporation,** with officers in the Grand Central Terminal, New York City.

R. B. Fisher, general sales manager of the **Buda Company,** Harvey, Ill., has been promoted to vice-president in charge of the sales and engineering departments of the railway division.

The American Car & Foundry Company has acquired the **Shippers' Car Line Corporation,** the **American Welding Company** is a subsidiary.

The Paige & Jones Chemical Company, Inc., has removed its executive offices from 248 Fulton street to 461 Fourth avenue, New York City.

W. M. Graves, Jr., has been made sales engineer representing the **Pyle National Company** and **Oliver Electric & Manufacturing Company,** who have established a branch office in the Boatmen's Bank Building, St. Louis, Mo.

R. J. Sharpe, district representative at Tulsa, Okla., of the **General American Tank Car Corporation,** Chicago, Ill., has been appointed general sales manager, with headquarters at Chicago, Ill. **J. V. O'Neil** has been appointed to succeed Mr. Sharpe at Tulsa, Okla.

Morris Ireland has been appointed branch manager at Cleveland, Ohio, for the **Westinghouse Electric Manufacturing Company,** to succeed **John Andrews, Jr.,** who has been transferred to Detroit, Mich., as Manning, Maxwell & Moore, Inc., New York, has purchased the name, good will drawings, and patterns of the Detrick & Harvey Machine Company, Baltimore In the future the Detrick & Harvey open side and convertible planers, standard double housing planers, and horizontal boring machines will be manufactured by the Putnam Machine Works, a subsidiary of Manning Maxwell & Moore, Inc. J. W. Neidhardt, formerly president of the Detrick & Harvey Company, will be associated with Manning, Maxwell & Moore, specializing in the Detrick & Harvey lines. The Detrick & Harvey plant, machinery and equipment at Baltimore will be liquidated in the near future.

L. S. Allen has been placed in charge of the newly opened Tulsa, Okla., office of the **Central Steel Company,** Massillon, Ohio. Mr. Allen has had experience in eastern steel mills and also has had many years with the oil drilling industry.

The Locomotive Firebox Company, Chicago, Ill., has appointed **C. S. Carter** as sales representative in the St. Paul, Minneapolis territory, with headquarters in the Baker building, Minneapolis, Minn.

The Gould Coupler Company has sold its friction draft gear and passenger buffer and platform business to the **Waugh Equipment Company.**

L. M. Hartzell, assistant district sales manager of the **Carnegie Steel Company,** Cincinnati, has resigned to enter the real estate business in that city.

Walton L. Woody, formerly manager of the Cleveland plant of the **National Malleable & Steel Castings Company,** has been made manager of the company's plant in Chicago, succeeding **P. W. Collin,** retired.

The Standard Steel Car Company has moved its Chicago office from the Fisher building to Tribune Tower, Chicago, Ill.

The United Pacific Lumber Corporation has been organized, with headquarters in Singer building, New York City, and will specialize in the sale of lumber to railroads and car companies. The officers of the company are as follows: **T. Fred Sowers,** president; **C. W. Cantrell,** vice-president; and **A. S. Tobias,** secretary.

The Sissen Supply Company has removed its headquarters from 2 Rector street, to Grand Central Terminal, New York City.

E. O. Shreve, manager of the San Francisco office of the **General Electric Company,** has been appointed manager of the industrial department, with headquarters at Schenectady, New York, succeeding **A. R. Bush,** deceased.

The Truscon Steel Company, Youngstown, Ohio, is planning the construction of a three-story office building to cost approximately $200,000.

The Pyle National Company, Chicago, following the purchase of the **Oliver Electric & Manufacturing Company,** St. Louis, Mo., has erected an addition to the former plant at Chicago, into which the Oliver Electric & Manufacturing Company has moved. **J. A. Amos,** vice-president and general manager of the Oliver Electric & Manufacturing Company, has been elected vice-president of the Pyle National Company.

The Kalamazoo Railway Supply Company has opened an office at 50 Church Street, New York City, in charge of **J. E. Murray** and **H. M. Clawson,** who will conduct its eastern domestic and export sales.

W. R. Walsh has been appointed to the sales department of the **Ewald Iron Company,** with headquarters in the Railway Exchange Building, Chicago, Ill.

Harlan A. Pratt has been appointed manager of the oil and gas engine department of the **Ingersoll-Rand Company,** New York City. Mr. Pratt was formerly connected with the sales department of the **Westinghouse Electric & Manufacturing Company.**

E. C. Wilson, sales director for the **National Safety Appliance Company,** with headquarters at Chicago, has been promoted to eastern manager, to succeed **K. E. Kellenberger,** who has resigned.

George W. Hoover, district sales manager of the **Buda Company,** Harvey, Ill., with headquarters at St. Louis, Mo., has been appointed eastern sales manager and export sales manager with headquarters at 30 Church Street, New York City.

P. J. Tierney has been made the St. Louis representative of the **Davis Brake Beam Company,** Pittsburgh, Pa., with headquarters in the Railway Exchange Building, St. Louis, Mo.

A complete reorganization of the sales department, involving the reallocating of the managing personnel and the creating of several new activities, has been announced by **E. D. Kilburn,** vice-president and general sales manager of the **Westinghouse Electric and Manufacturing Company,** effective April 1.

The change, which involves all departmental sales managers of the company, consists of the following appointments: assistant to vice-president, **E. H. Sniffin,** formerly manager power department; director of sales, **T. J. Pace,** formerly manager supply department; central station manager, **G. H. Froebel,** formerly manager marine department; industrial sales

manager, J. M. Curtin, formerly manager industrial department; transportation sales manager, M. B. Lambert, formerly manager railway department; assistant director of sales A. C. Streamer, formerly assistant to manager supply department; generating apparatus manager, H. W. Smith, formerly general engineer; traction apparatus manager, A. J. Manson, formerly manager heavy traction division, railway department; motor apparatus manager, O. F. Stroman, formerly assistant to manager, industrial department; switchgear appartus manager, R. A. Neal, formerly head of switch section, supply department; and distribution apparatus manager, G. A. Sawin, formerly assistant to manager, supply department.

The announcement is the culmination of a reorganization of the Westinghouse sales system which has been in course of development for some time. Its effect, according to Mr. Kilburn, will be to form a more flexible organization now necessary to serve and anticipate the needs of electrical apparatus users, due to the tremendous development of the industry.

Mr. Sniffin, newly appointed assistant to vice-president, became prominent as commercial aid to George Westinghouse, founder of the Westinghouse Companies. He is one of three men who were directly responsible for the introduction of the steam turbine to the United States. His career with the company dates from his sixteenth year, when he became a stenographer in the New York offices of the Westinghouse Church, Kerr & Co., who were, at the time, sole agents for the Westinghouse Machine Company. By studying mechanical engineering in his spare time, he became a salesman of power plant equipment at the age of 22. In 1900 he was made sales manager of the company he had joined as a stenographer, and three years later was appointed sales manager of the Westinghouse Machine Company. In 1906 he was made vice-president in charge of sales for the company and in 1915 when the Electric Company absorbed it, was made manager of the power sales department.

The new director of sales, Mr. Pace, is a native of Pittston, Pa., but received his first business experience in New York City, when at the age of 20 years, he joined a contracting firm there. In 1899 he was engaged by the Manhattan General Construction Company of Newark, N. J., which, at the time, was owned by George Westinghouse. During the latter part of the three years Mr. Pace was with the Manhattan Company he held the position of assistant to general manager. In 1902 when the Manhattan Company was purchased by the Westinghouse Electric Company, Mr. Pace moved to East Pittsburgh, where he was given charge of illuminating apparatus in the detail and supply correspondence department. Three years later he was made manager of what was termed the illuminating and rectifier sections. In 1915 Mr. Pace was made assistant to manager of the supply sales department, an outgrowth of the former detail and supply department. Five years later he was made assistant manager of his department, a position he held to 1922, when he was appointed manager.

L. E. W. Bailey, who for some years past has been railroad sales manager for the Dearborn Chemical Company, Limited, with headquarters at Toronto, Canada, has joined The Superheater Company, Limited of Montreal in the capacity of service engineer. Previous to his connection with the Canadian Pacific and Great Northern Railways having worked up in the motive power department from fireman and engineer to division master mechanic. He has also served considerable time as a locomotive foreman.

Obituary

William Finley, 64-years-old retired president of the Chicago & Northwestern Railway, civil engineer, and one of the leading railroad authorities of the country, died suddenly of pneumonia at his home in Wheaton, Ill., March 17.

Mr. Finley was born January 22, 1862, in Newcastle county, Del., and entered the engineering field as a draftsman for the Edge-Moor Iron Co., of Wilmington, Del., which built the East River bridge in New York. He entered railway service in October, 1887, as draftsman for the Chicago, Milwaukee & St. Paul Railway, being appointed assistant engineer in charge of designing in the bridge and building department in 1891. He was appointed engineer of bridges of the Chicago & North-Western Railway in 1892, serving in that capacity until 1902, when he was appointed principal assistant engineer.

Mr. Finley was appointed assistant chief engineer of the Chicago & Northwestern Railway in 1906 and promoted to chief engineer in 1913. He was elected president in 1918, which position he held until June 23, 1925. Since leaving the Northwestern, Mr. Finley has been practicing as a consulting engineer, with headquarters in Chicago.

Mr. Finley belonged to the American Society of Civil Engineers; the Western Society of Civil Engineers, of which he was past president; the American Railway Engineering Association, which he had also served as president; Franklin Institute; American Association of Engineers, of which he was president in 1918; the Union League, and many other railroad clubs.

Howard G. Hetzler, president of the Chicago & Western Indiana Railroad and of the Belt Railway Company of Chicago, died at the age of 63 at his home in Hinsdale, Ill. Mr. Hetzler entered the service of the Monon line in 1885, soon after his graduation from the University of Michigan. He was appointed a superintendent on the Chicago, Burlington & Quincy Railroad in 1899 and in 1905 he was elected president of the Metropolitan Elevated Railroad, Chicago. He resigned from that position in 1910 to take charge of the affairs of the Chicago & Western Indiana Railroad, and of the Belt Railway as president.

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A Powerful Three-Cylinder Locomotive for the Union Pacific Ry.

Details of a New Design for Fast Freight Service

The 2-8-8-0 type Mallets which for several years past have been in use on the Union Pacific are among the most successful engines of this type that have been built. During certain slack times when these Mallets were not urgently needed in the mountainous district, they were placed in road service between Green River and Laramie, the maximum grade being 8 per cent, by which remarkable reductions were obtained in operating costs. But, also of making the same speeds as are now made by the 2-10-2 and Mikado locomotives. In other words, an increase in permissable speed from twenty to forty miles per hour, and an increase in average speed over the district from twelve to better than twenty miles per hour.

The amount of power required, coupled with a weight limit of 59,000 pounds per pair of drivers, made six coupled axles a necessity. Such a design was impossible

New 4-12-2 Type Three-Cylinder Locomotive for the Union Pacific Railroad, Built by the American Locomotive Company

due to the fact that the Mallet locomotive is inherently a low speed machine, they could not be used in this district during the busy season as they would block the road.

Since 1917, the standard locomotive for fast freight service in the mountain districts has been the 2-10-2 type two-cylinder locomotive with a tractive power of 70,450 pounds. About a year ago, as a result of the success of the three-cylinder locomotive on several railroads, the management of the Union Pacific purchased from the American Locomotive Company one three-cylinder 4-10-2 type locomotive No. 8000 for demonstration and comparison with the above referred to 2-10-2 type. Engine 8000 was built as nearly identical to the 2-10-2 type as the three-cylinder design would permit, having the same weight on drivers, size of drivers, grate area, and practically the same boiler.

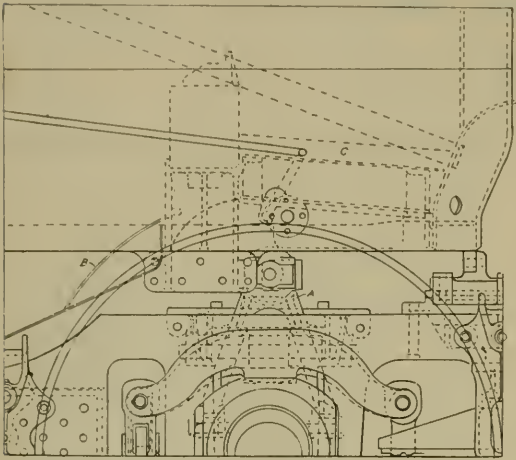
The comparative tests conducted between the three-cylinder 4-10-2 and the two-cylinder 2-10-2 developed that the three-cylinder engine No. 8000 can and does regularly handle twenty per cent more tons in regular service, with an expenditure of sixteen per cent less fuel per thousand gross ton miles.

As a result of this it was decided to design a locomotive for fast freight service to be capable not only of hauling the present Union Pacific Mallet locomotive tonnage, but on a two-cylinder engine with main rods connected on a single driving axle. But the three-cylinder engine, transmitting its power through two main driving axles, in combination with smaller outside cylinder and distributing the stresses more equally over the whole frame structure, made such an arrangement possible, together with comparatively high speed and greater power. The final stresses transmitted are, therefore, somewhat less on the 4-12-2 design than they are on a 2-10-2 with outside cylinders of larger dimensions.

The problem of arranging such a long wheel base to negotiate a sixteen degree curve was solved by installing the lateral motion device, described in the March, 1926, issue, of Railway & Locomotive Engineering, at the rear as well as at the front driver, and using a four-wheel engine truck, and a trailer, both having great flexibility. The engine, as built, successfully passes sixteen-degree curves with all wheels flanged excepting No. 4, which has blind tires. However, it has been decided that future engines will have all drivers flanged.

After a preliminary study of the proposed 4-12-2 type, the matter was submitted to the locomotive builders, and engine No. 9000 represents the combined and co-operative mechanical effort of the Union Pacific Railroad officials and those of the American Locomotive Company.

A 63-inch wheel is quite generally considered standard for fast freight service. In this particular case, however, it was found that a good crank axle disign demanded a 67-inch wheel, which in turn improved the whole design for the work intended. The boiler presented quite a problem. Limited in weight to 59,000 pounds per pair of drivers, it was also desired to keep the total weight as low as possible. To get a firebox to burn semi-bituminous coal, it was necessary to secure a large firebox volume combined



Front End of Firebox Showing Gaines Wall and Location of Driving Wheel on Union Pacific 4-12-2 Type Locomotive

with length of flameway and firebox depth. Both volume and length of flameway were secured by a combination of the Gaines wall and internal combustion chamber. Previous engines equipped with the Gaines wall did not have a sufficient depth from the crown sheet to the top of the grate. A satisfactory depth was obtained, in this case, by allowing the rear driving wheel to stick up between the inside of the throat and the front face of the Gaines wall. This novel arrangement is shown in the partial side elevation, and is made possible by the use of the Gaines wall, which also provides for the greater depth of firebox which its own efficiency demands; for with the depth of firebox here used, the top of even a 63-in. diameter wheel would have risen above the bottom of the foundation ring. As it stands, even the lateral motion device *A* rises above the bottom of the foundation ring and enters the firebox. The space above the wheel and back of the wall is enclosed by a guard *B* having a clearance of about 4½ in. above the wheel flanges while in front of the wall and over the top of the wheel there is a still greater clearance beneath the brick floor *C*.

In front of the throat sheet, which is itself 2 ft. 9 in. ahead of the front face of the Gaines wall, there is a combustion chamber 6 ft. 8½ in. long.

The use of flexible staybolts in the firebox and combustion chamber follows current practice in that they are used in but two rows at the back all of the way down to the foundation ring, and but one row at the front. Then the first fourteen horizontal rows above the ring are all fitted with hollow rigid bolts, except for a triangular space in the upper corners that is bounded by six horizontal and vertical rows; which are flexible. Above this there are seven rows of flexible stays. They are also used in the throat sheet and in the upper portion of the sides of the combustion chamber.

It was also desired to retain the same length of tubes (22 ft.) as used on the railroad company's other engines. While seemingly this gave a relatively short tube for a boiler of this size, the long distance from front tube sheet to the cylinder center should in turn improve the draft condition by evening the pull on the upper and lower flues.

The total overall length of the boiler at the bottom is 56 ft. 3 7/16 in. This is divided as follows:

Firebox:	
Back end to back of Gaines wall	12 ft. 7⅜ in.
Thickness of Gaines wall	10½ in.
Front of Gaines wall to combustion chamber 2 ft. 9 in.	12 ft. 2⅞ in.
Combustion chamber	6 ft. 8½ in.
Tubes	22 ft. 0 in.
Smokebox	11 ft. 4 1/16 in.
	56 ft. 3 7/16 in.

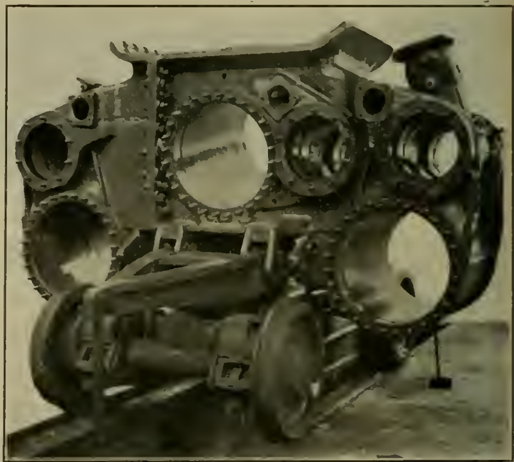
The length of the boiler at the top is 2 ft. 2 11/16 in. shorter than the bottom, due to the slope of the back head.

The firebox is the largest to which a Gaines wall has ever been applied and has a volume of about 603 cu. ft. to which the combustion chamber will add about 202 cu. ft. making a total of about 805 cu. ft.

The dome is the largest ever built by the American Locomotive Company, and is 40 in. inside diameter. It is placed on the rear shell course at a point where the outside diameter is 8 ft. 6 in. and the plate 1 in. thick.

The cylinders and saddle are formed of steel castings and are the first instance in which that material has been so used in a three-cylinder locomotive.

The general design is very similar to the cylinders used



Saddle and Cylinders of 4-12-2 Type Locomotive

on the engine for the South Manchurian Railway which were illustrated in Railway & Locomotive Engineering for November, 1924.

The right hand cylinder and the greater portion of the saddle, with the central cylinder, are cast in one piece and the left hand cylinder is bolted to the other in the usual manner. This center cylinder slopes at an angle of 9½ degrees from the front down to the back, which makes a difference of 7 3/16 in. in the height of the two ends.

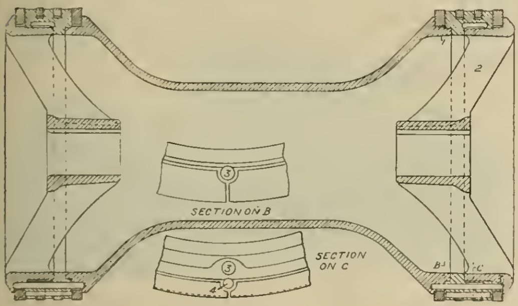
In studying these castings it will be found that great uniformity of thickness has been preserved throughout.

This has been set at 1 in. with a reduction to ⅞ in. in some places, such as the cylinder shell; but even the flanges by which the castings are fastened together does not exceed this amount. The one place where an excess of thickness is indulged in is in the pads where the frames are attached.

The smokebox is flattened at the bottom for a width of 4 ft. 3 in. for which there is a corresponding flat seat on the saddle. This serves to afford a better bearing for the boiler support.

The cylinder bushings are ⅝ in. thick and are pressed in from the front end, and are made not only to set up against a shoulder in the cylinder bore at the back but have a lip at the front resting against a shoulder. They are thus held between the front cylinder heads and the shoulders so that any longitudinal displacement is prevented, should there be a looseness occasioned by difference in expansion of the metals of the shell and bushing.

Steam enters through a common 8½ in. pipe on the right hand side for the right and center cylinders. In the casting there is a partition that is beneath the inner edge of the opening, instead of being in the center, as in the South Manchurian engines. The passage on the



Piston Valve for Union Pacific 4-12-2 Type Locomotive

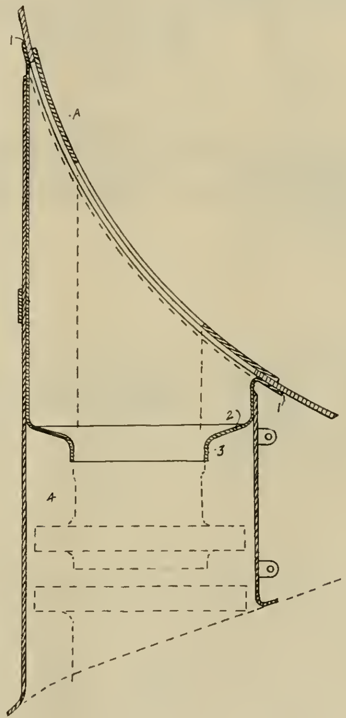
outside of this partition leads to the right cylinder and that on the inside to the center cylinder. It, therefore, acts as a deflector by which any water that may be entrained by the incoming steam is deflected away from the center cylinder and into the right hand one, from which it can be more easily drained.

The steam passages from the inlet opening to the steam chests are straight and directed to the center, while the exhaust passages from the ends of the steam chest have the minimum of curvature and are large and free. There are three exhaust openings, at the center of the saddle for the right, center and left cylinders respectively, so that there is no mingling of the jets until they reach the exhaust pipe where they have an upward movement, thus preventing any one jet from developing a back pressure in another cylinder, but serving by its suction action, to lower any that may already exist. In this case the three openings are arranged side by side laterally of the engine instead of on the longitudinal center as in the Manchurian engine. An arrangement that provides for more direct and larger passages.

The passages in the left cylinder casting vary slightly from those at the right. The steam pipe, having only one cylinder to supply is 7½ in. instead of 8½ in. in diameter, as at the right, and the exhaust passage, not having to be carried over the top of the steam chest of the center cylinder, is considerably larger than at the right, though the two openings into the exhaust pipe are of the same dimensions. All of these openings are rectangular with filleted corners.

The cylinders are bolted to the frames by fifteen 1¾ in. diameter bolts on each side. For the details of the general arrangement of the cylinder steam chests and passages reference is made to the illustration of the cylinders of the South Manchurian engine alluded to.

The hollow piston valve presents some points of interest. The first of which is the use of eight packing rings instead of the usual number of four. This is the railroad company's standard. As constituted, the valve, as a whole, is built up of thirteen parts. There is the main central portion which forms the steam cavity; the two spiders, one at each end, the two bull rings and the eight packing rings. As shown in the engraving the bull ring slips on over the central portion with a small shoulder



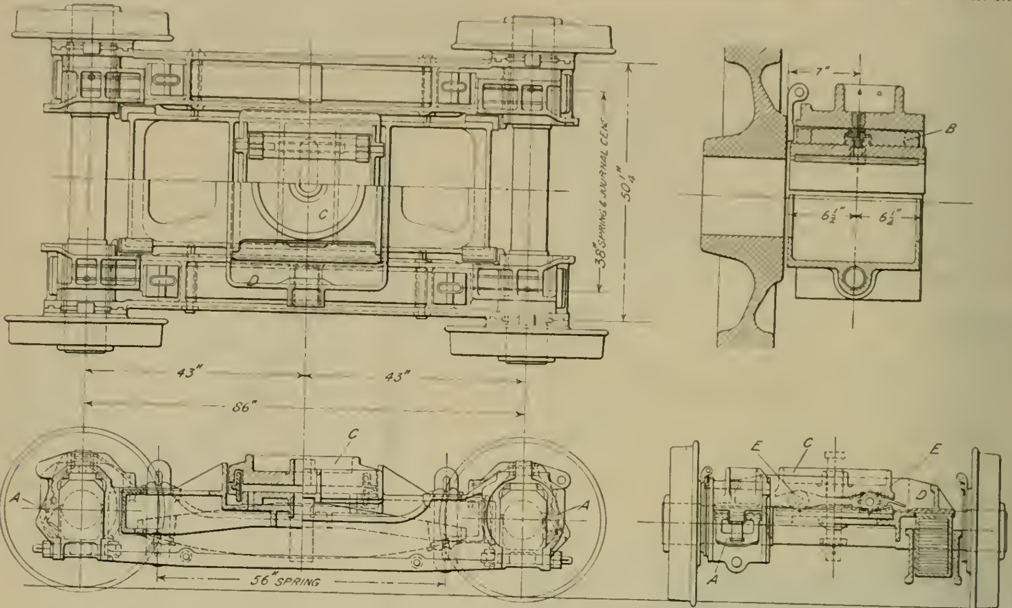
Steam Pipe Casing for Union Pacific 4-12-2 Type Locomotive

bearing 1, and the spider 2, is slipped inside of it; the three parts being held in alinement by the dowels 3, that pass through the bull ring beneath the packing rings.

The packing rings are made of gunmetal and are first turned to a diameter of 14⅝ in., the steam chest being of 14 in. diameter. They are then cut with a slot 7/16 in. wide and closed in with a temporary liner 1/32 in. thick between the ends and turned or ground to the exact diameter of the bushing. When in position, the partings are at the bottom and are prevented from turning by a second dowel 4 that is inserted in the bull rings.

The outside valves are driven direct by the Walschaert gear, and the central valve by the Gresley gear, which consists of a combination of horizontal levers attached to the three valve stems and located in front of the smokebox; a design that was illustrated and described in RAILWAY & LOCOMOTIVE ENGINEERING for November, 1924.

Closely associated with the cylinders is the patented flextite steam pipe casing. It is shown in the engraving. At 1 it is welded to the smokebox for the full circumference so as to make an air tight joint, while the steam pipe casting 2 is made in halves and is welded at the top and bottom at 3 and at the centers. The space between the casing and the pipe is packed with asbestos blocks securely wired in place, and at the joint of the steam pipe and cylinder at 4 they are made in line with the air joint



Front Truck for Union Pacific 4-12-2 Type Locomotive

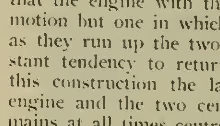
and casing and wrapped outside. The liner plate *A* is spot welded to the inside of the smokebox.

The advantages possessed by this casing are that it not only presents a better appearance than the ordinary casing due to the heavier material of which it is made, and the more rigid support, and the considerable net saving in weight, but also the elimination of castings with the attendent machine work and chipping. There is no packing; it is absolutely air tight from shopping to shopping; it effects a saving in fuel, and when applied no further attention is necessary until the steam pipe itself should have to be removed. In other words, there is an entire absence of roundhouse inspection and repacking which, ordinarily, is required approximately once every thirty days.

The four-wheeled engine truck embodies a number of novel features, which make for accessibility and a reduction of the maintenance costs. The truck frame is built up of three steel castings; the two side pieces and a transom connecting the two and known as a squaring frame. The side pieces introduce a novelty in engine truck construction in that they have the oil boxes cast integrally with the frame, and these boxes instead of requiring a dropping of the cellars for packing are provided with spring covers *A* like an ordinary car journal which are at the ends of the truck. The packing is thus made easily accessible at all times.

The whole weight of the frame thus rests directly upon the journals without any spring intervention. The journal bearings carry the load through adjustable wedges *B*, in the same manner as the tender bearings, by which an equalized bearing pressure over the whole area of the journal is insured, a method that has proven its value by its elimination of hot journals.

The truck center plate *C* rests upon the truck bolster *D* through two rollers at whose ends there is a toothed gear meshing in with inclined racks on the bolster and center plate. This construction is clearly shown on the half cross section and end elevation. It will be seen from this that the engine with the center plates has a free lateral motion but one in which the rollers must lift the engine as they run up the two inclines, and which have a constant tendency to return to the central position. With this construction the lateral motion is confined to the engine and the two center plates, while the bolster remains at all times central with the truck frame.



Truck Journal Box for Union Pacific 4-12-2 Locomotive

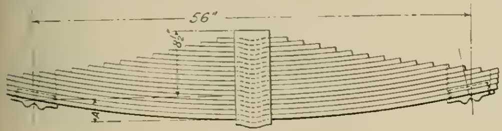
The bolster is carried at each end, by a semi-elliptic spring of the form shown in the engraving.

A peculiarity of these truck springs as well as those of the driving axle and trailer truck is that the master leaf is straight when free, that is the distance $X = 0$, and then, when loaded there is the reverse camber as shown. This is a standard of the railroad company.

The truck spring consists of seventeen plates 5/8 in. thick of which four are full length and 56 in. long from center to center of hangers. The plates are slotted at the ends for the admission of the hangers. The springs thus act as equalizers for the even distribution of the weight.

The journal boxes, as thus cast integrally with the truck frame, are protected from wear by hub liners that are made in two halves. These are held together by a

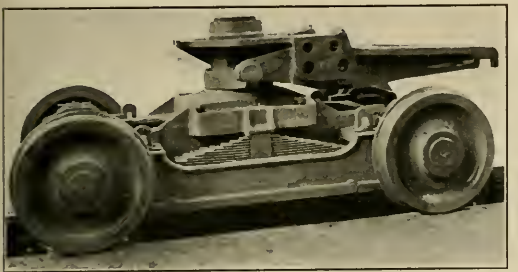
¾-in. bolt, double nutted and fitted with a cotter. Each half slides down from the top in inwardly sloping dovetailed grooves cut in the journal box portion of the frame. Their lubrication is provided for by oil cavities cast in the top of each half; and, when worn may be removed, rebabbitted to normal thickness and replaced without disturbing any of the other parts of the truck. Liners of this design have now been in service for a period of two years, and have established their serviceability and utility from a



Truck Spring for Union Pacific 4-12-2 Type Locomotive

maintenance standpoint, in that they provide an exceeding rapid method of making renewals and for keeping the engine out of service for the shortest possible time. The device is patented as well as the truck as a whole.

The truck is equalized with the front pair of drivers, after the manner used on consolidation and other engines

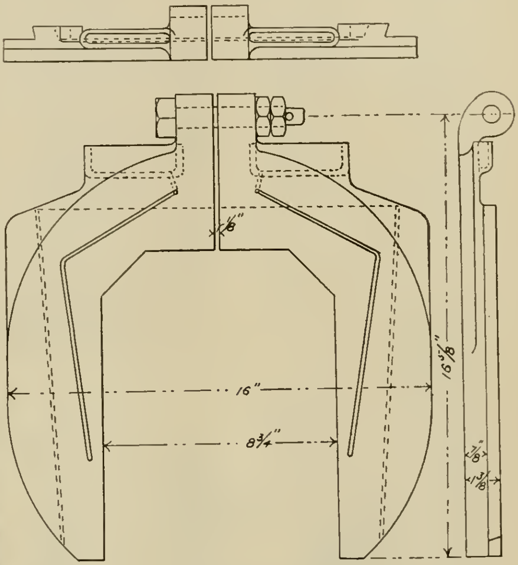


Four-Wheeled Truck of 4-12-2 Type Locomotive

having two-wheeled leading trucks. This equalization is carried back to the second pair of drivers. The rear equalization starts at the third pair of drivers and extends back to and includes the rear truck.

At the front, the driver and truck equalizer, instead of taking hold beneath the center pin as in the case of the pony truck, is forked at the front end and has a bearing on a ring that encircles the center pin and rests upon the upper center plate. At the same time the weight of the engine is carried by a supplementary casting bolted to the bottom of the saddle. The load is thus transferred to the driver and truck equalizer at a point 19½ in. back of the center pin, thus serving to increase the load upon the truck as compared with what would be imposed, were the saddle weights to rest directly upon the center plate.

Another standard of the railroad is a novel dumping arrangement for the ashpan. It uses a freight car brake wheel on the end of a horizontal shaft in which are two

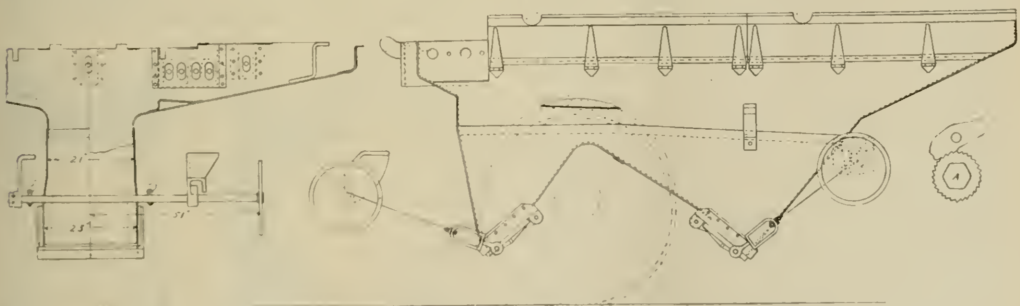


Hub Liner for Truck Boxes of Union Pacific 4-12-2 Locomotive

eyes 5 to which ¼ in. straight link chains are attached running to a clevis attached to the hopper door of the ashpan. When the chain is wound about the shaft and the latter is held by a pawl and ratchet *A* the door is held closed. When the chain is slackened the door drops open by gravity.

The valve gear crosstie, or as it is ordinarily called, the guide yoke, is of a novel design and is the first use of a single steel casting acting as a support for both the back end of the guides, and the link and a crosstie for the frames.

The link trunnions have a bearing at *B* and the link works in the space *A;* while the radius rod extends through the opening *C*. The casting has a lateral length of 10 ft. 5 in. It is L-shaped with a vertical depth of 13 between and 16¼ in. at the frames. This vertical leg is solid. The horizontal leg is 23¾ in. wide and is lightened

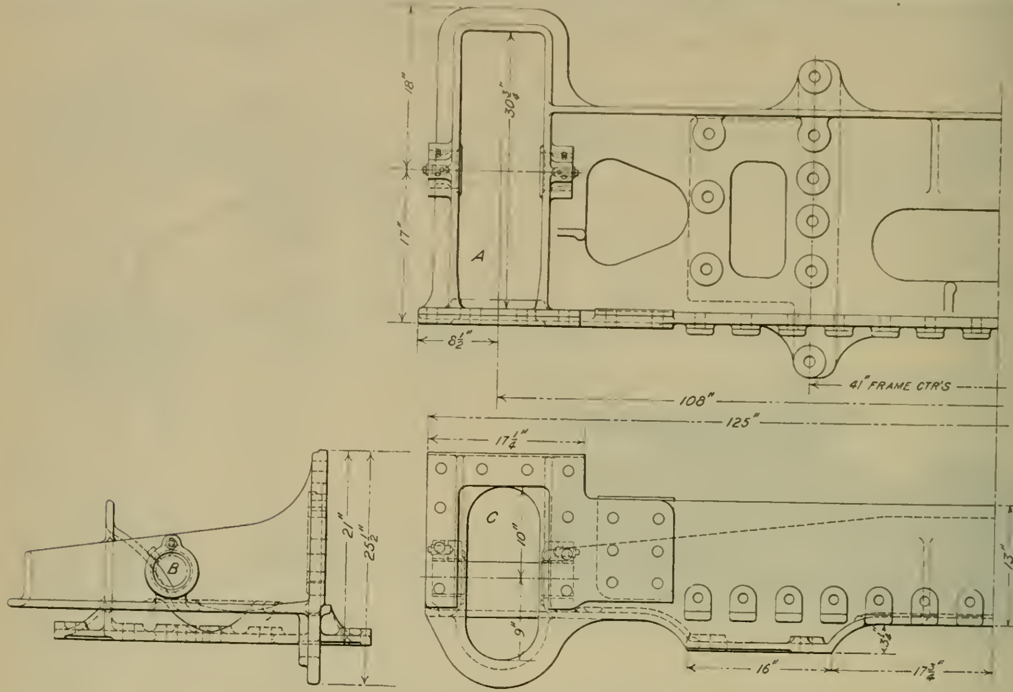


Ashpan Dumping Arrangement on Union Pacific 4-12-2 Type Locomotive

by five holes as shown on the engraving. A patent has been applied for this design. The guide yoke proper is bolted to the front face of the casting and is not shown in the engraving.

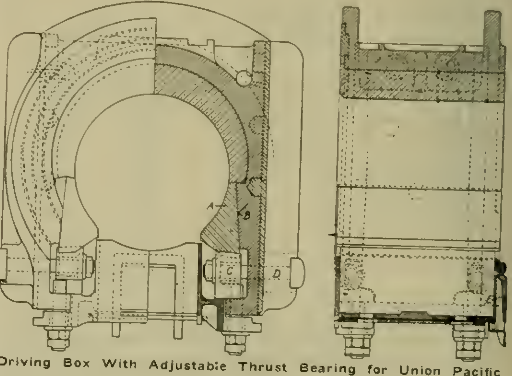
The driving boxes, as applied to both the main and the crank axles, are fitted with cheek pieces *A* extending below the center line of the axle for the purpose of taking up the side wear. These cheek pieces operate in the same manner as those shown in connection with the South Manchurian engines illustrated in the November, 1924 issue of RAILWAY AND LOCOMOTIVE ENGINEERING except that in that engine the cheek pieces were adjusted by a bolt from below pressing directly against the bottom of the piece. In this case the cheek piece *A* is set against a bevel *B* and held in place by a wedge *C* that can be drawn outwardly by a nut on the bolt *D*. When used on the crank axle the grease lubricant must be applied from the bottom. For this purpose the cellar is fitted with a spring cap *E* at the end like a car box cover, which can be raised and access to the interior of the cellar obtained without taking it down or removing any of the adjacent parts. In order to facilitate this the pedestal tie is arched down in the middle. The cellar is also made of sufficient strength and is so fitted that it forms a spreader in the box and prevents the sides from closing in and also forms a support for the wedge *C* that carries the supplemental bearings. Many of the features of this box have also been patented.

One of the minor parts of the engine that contributes to the reduction of maintenance costs is the handrail post, which is one of the standard constructions of the American Locomotive Company. The ordinary handrail is of such a permanent character that the removal of any portion of the jacketing involves considerable dismantling. This post consists of a 3/4 in. stud *A* screwed into the shell over which a casting *B* is slipped. This has a groove for the reception of the rail *C* which is held in place by a clamp *D* having a bearing at 1 on the top of the casting and the whole is fastened by the nut on the stud. A running off of the nut loosens the whole so that everything can be lifted out of the way and the jacketing removed.



Single Piece Valve Gear Crosstie of the Union Pacific 4-12-2 Type Locomotive

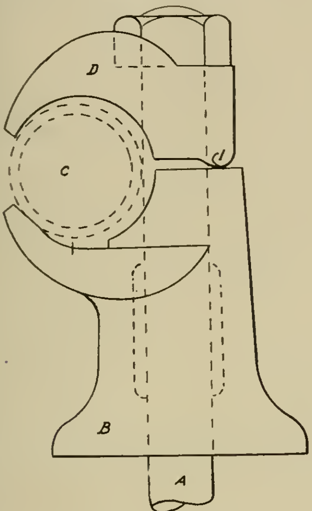
This design permits the use of a single length of handrail post throughout the engine, since the handrail pipe is applied before the caps are fastened down. By removing the caps from two or more adjacent posts, the handrail posts may be removed without disturbing the



Driving Box With Adjustable Thrust Bearing for Union Pacific 4-12-2 Type Locomotive

handrail itself and the boiler jacket raised for caulking the boiler to stop leaks. This is a great improvement over the use of the solid handrail columns which require the removal of the entire handrail before a portion of the boiler jacket could be raised. Handrails used with this type of post are frequently utilized to carry the headlight or train control wiring.

Among the specialties on refinements of locomotive practice included in the design are the precision type "F" power reverse gear, adjustable wedges, driving box lubricator, radial buffer, unit safety bar and flexible conduit, all products of the Franklin Railway Supply Company, Inc. The type "E" superheater of the Superheater Company and the Worthington feed water heater is used.



Handrail Post for Union Pacific 4-12-2 Type Locomotive

The Locomotive Stoker Company furnished the Elvin type of mechanical stoker.

The lateral motion device on the front and back drivers and the four-wheel engine truck are of the American Locomotive Company's design. Both the force feed and hydrostatic lubricators were furnished by the Nathan Manufacturing Company. The trailer truck and cradle, bumper beams, tender frames and body center plates and also the tender truck were furnished by the Commonwealth Steel Company.

The following list of principal dimensions gives those of this 4-12-2 locomotive in comparison with those of the 2-8-8-0 Mallet engine.

Type	4–12–2	2–8–8–0
Cylinder diameter h.p.	27 in.	26 in.
Cylinder diameter l.p.		41 in.
Piston stroke	31 in. (inside)	32 in.
Piston stroke	32 in. (outside)	
Tractive power, simple	96,650 lbs.	135,484 lbs.
Tractive power, compound		96,627 lbs.
Factor of adhesion, simple	3.67	3.76
Factor of adhesion, compound		4.51
Wheel base, driving	30 ft. 8 in.	15 ft. 6 in.
Wheel base, rigid	17 ft. 6 in.	15 ft. 6 in.
Wheel base total engine	52 ft. 4 in.	50 ft. 6 in.
Wheel base, total engine and tender	91 ft. 6½ in.	87 ft. ½ in.
Working pressure, lb. per sq. in.	220	210
Firebox, length	184¼ in.	132⅛ in.
Firebox, width	108¼ in.	96 in.
Firebox, length combustion chamber	80½ in.	58 in.
Firebox, depth center lowest tube to grate	21¼ in.	19 in.
Tubes, diameter	3½ in.	5½ in.
Tubes, number	40	48
Flues, diameter	3½ in.	2¼ in.
Flues, number	222	246
Flues and tubes, length	22 ft.	23 ft. 6 in.
Flues and tubes, spacing	11/16 in.	¾ in.
Heating surface, tubes	803 sq. ft.	1618 sq. ft.
Heating surface, flues	4459 sq. ft.	3394 sq. ft.
Heating surface, firebox and combustion chamber	529 sq. ft.	337 sq. ft.
Heating surface, syphons		97 sq. ft.
Heating Surface, arch tubes	62 sq. ft.	
Heating Surface, total	5853 sq. ft.	5446 sq. ft.
Superheater surface	2560 sq. ft.	1320 sq. ft.
Grate area	108.25 sq. ft.	88.1 sq. ft.
Wheel diameter, driving	67 in.	57 in.
Wheel diameter, engine truck	30 in.	30 in.
Wheel diameter, trailing	45 in.	
Wheel diameter, tender	33 in.	33 in.
Weight, front truck		80,000 lbs.
Weight, driving wheels		355,000 lbs.
Weight, trailing truck		60,000 lbs.
Weight, total engine		495,000 lbs.
Weight, tender		287,000 lbs.
Smokestack, diameter	20 in.	19 in.
Smokestack, above rail	16 ft. ⅜ in.	15 ft. 10 in.
Tank, style	Cylindrical	Cylindrical
Tank, capacity water	15,000 gals.	12,000 gals.
Tank, capacity coal	21 tons	20 tons

The locomotive embodies straight engineering throughout, no freak schemes being used, the design as a whole merely combining a number of accepted features in a novel way in order to obtain the characteristics desired within the weight and a clearance limitations specified.

Train Brake Tests

Railway executives from the leading railroads have inspected the equipment used in the investigation being made by the American Railway Association at Purdue University of the elaborate series of tests of train brakes ever undertaken.

These tests are being conducted under the direction of H. A. Johnson, Director of Research of the American Railway Association. The purpose of the tests is to determine what improvements can be made in respect to the present standard of brakes now used by the railroads of this country. Thirty engineers are engaged in the work.

The tests, which began this spring and are expected to cover a period of one year, are being conducted in a separate building which has been especially set aside for the work at Purdue University. In this building has been installed the complete air braking equipment from two modern locomotives as well as the brake equipment from one hundred freight cars so that the tests watched by the railroad executives were equivalent to tests that would come from the actual operation of a train consisting of two locomotives and one hundred freight cars on a railroad.

Most of the time so far has been devoted to testing the present standard brakes now in use on the railroads of this country with a view of providing a basis of comparison for subsequent investigations. Later, brake equipment which manufacturers claim will prove to be an improvement over the present standard will be tested. Upon completion of the work at Purdue University, various brake devices will be given road tests for the purpose of developing whether or not they meet practical road conditions satisfactorily.

The railway executives who visited Purdue University were conducted by Dean A. A. Potter and Prof. G. A. Young.

Annual Convention of the Air Brake Association

New Orleans Meeting Largest in History

The thirty-third annual convention of the Air Brake Association was held at New Orleans, La., May 4 to 7, inclusive. Over 800 members and guests registered and the supply exhibit provided by 51 companies made it by far the largest held in the history of this Association. President R. C. Burns presided and in the course of his opening address he said:

Like every other division of railroad transportation, the air brake must, of necessity, keep pace with the constantly increasing developments and improvements in the more efficient and safe handling of passengers and lading. This necessitates constant vigilance in the way of practical apparatus, installation and maintenance. Many rules and regulations are essential in order that equipment from one road may be thoroughly interchangeable as to functioning and performance on another. Without such regulations we could not expect to progress, and in order that our progress may continue, it is vitally important that air brake men fulfill their duty in seeing that regulations are carried out.

When we look broadly upon the accomplishments of railroads in this country, as compared with those abroad, in facilitating exchange of freight, we have just reason to feel proud of our work. A freight car loaded in Canada can be transported to any part of this great continent without any change in its equipment or transfer of its lading.

While a healthy rivalry and competition exists among properties under separate ownership, there is no selfish division between the officers and employees of one road and those of another when it comes to matters pertaining to the common good. This is an accomplishment in which we, as air brake men, have had a prominent part, and we are, therefore, justly entitled to a feeling of pride in our vocation and in the railroad air brake department which we represent.

The safety factor, though of essential importance, is but a part of our extensive field of endeavor. The brake equipment must be equal to the demands of traffic in every particular and still render the required service as to safety.

You are aware of the efforts being made by the American Railway Association to analyze the existing equipments and the art of controlling trains by means of air brakes in general, with a view toward formulating improvements wherever possible or desirable. This is in the common interests of all railroads of the country as a whole. We shall await with much interest the results of these studies, and I bespeak for this association your whole-hearted co-operation and willingness to render any service that may be desired.

Report on Brake Pipe Leakage

Your committee on Brake Pipe Leakage was appointed during the winter of 1924 by President G. H. Wood and a preliminary report was submitted at the Montreal meeting of that year.

A progress report was submitted at the next annual meeting of the association held at Los Angeles during May, 1925. At that time that committee realized that the limited number of cars tested, as well as the comparatively few locations where tests were conducted, made the data more or less unreliable for use as the basis for determining the general condition of brake pipe leakage on railroads. It was decided that the evidence on this point could be greatly strengthened by further tests at other locations. The committee was desirous of making a more complete study of the entire subject with a view to recommending action by this association in dealing with the brake pipe leakage problem.

The subject of brake pipe leakage is very broad and this committee has found that it is impossible to cover it so that all phases are fully investigated, discussed and analyzed. The committee has endeavored to compromise by treating the subject in such a general way that this association will be justified in accepting and acting on the committee's recommendations.

This report, therefore, can be regarded as a final report on this subject, unless it is the expressed wish that a further investigation should be conducted.

There can be no doubt that the combined running and standing test data show that an exceedingly wasteful leakage condition exists on the average train in service. In order to improve this condition it is essential that some standard of excellence should be established for maintenance. Your committee has made a study of a large number of tests with the object of setting such a leakage limit.

The considerations which determine what the limit should be are several, such as economy, bad effect on trainhandling, and possibility of engine failure on account of an overloaded compressor. Economy dictates that the limit should be set at a very low point so as to eliminate all waste but this might be objectionable because in some cases it would mean a hardship. The average leakage rates which exist on long trains are such that the locomotive compressor is frequently overtaxed. If the leakage limit is set to fix the maximum leakage for any train at a point which will insure a good margin against overloading the compressor, a very large saving will result and the intergrity of the brake as well as the quality of its service will be improved.

The leakage limit which your committee wishes to suggest and recommend is 36 cu. ft. of free air per min. This means that when a train will not charge to at least 65½ lb. when supplied from a pressure of 70 lb. through the ¼ in. orifice of the testing device, the train must be inspected and repaired until it will charge to 65½ lb. or more.

Conclusions

1—That the data of brake system leakage presented in this and the previous report is fairly representative of the leakage condition as it exists in current freight train service.

2—That the average of the relation between brake pipe leakage and the leakage from the auxiliary reservoir volumes is nearly one to one and frequently the ration is greatly exceeded.

3—That both the brake pipe and auxiliary reservoir leakages are decidedly detrimental to brake operation.

4—That the modern long freight train must have its average brake system leakage reduced if it is to be handled safely and efficiently.

5—That about 97 per cent of all compressed air furnished to operate train brakes is wasted in maintaining pressure against leaks.

6—That the present high cost of operating and maintaining air compressors on locomotives will be reduced proportionately to any reduction in the average brake system leakage.

7—That all trains should be tested for brake system leakage before leaving a terminal.

8—That a brake system leakage limit should be fixed to govern how much will be tolerated.

9—That the brake system leakage testing device described in this report is a suitable device for the convenient and accurate measurement of train leakage.

10—That better brake installation design will facilitate the maintenance of a lower average brake system leakage rate.

11—That the use of reinforced pipe fittings will be of great assistance in the reduction of leakage and maintenance expense.

Recommendation

1—That this association go on record as favoring a brake maintenance program which will reduce leakage.

2—That the members of this association should assist wherever possible in establishing the practice of testing trains for leakage while they are being prepared to leave the terminal.

3—That the brake system leakage testing device as described in this report or its equivalent be adopted as the means of testing train leakage.

4—That for the present, a leakage limit of 36 cu. ft. of free air per min. per train be established. This means that a train will be condemned for leakage if it does not charge to 65.5 lb. or higher when supplied from 70 lb. pressure through a 1/4 in. orifice.

5—That the American Railway Association be requested to consider the testing device and leakage limit here recommended as a basis for a freight brake maintenance rule.

6—That a study be made of brake installation designs with a view to improving the mounting of brake equipment devices, the clamping of pipes and the elimination of threaded joints wherever possible. It is suggested that this subject be considered for action by the committee on recommended practice.

7—That this report be accepted as final by this association and the committee be discharged.

(This report was signed by Chairman C. H. Weaver, W. W. White, and C. B. Miles, and R. E. Miller.

Retaining Valve Testing

The retaining valve and its pipe have not received the attention necessary to keep them in proper condition for roads using them. A reasonable degree of perfection will not be reached until level grade roads realize that their responsibility is equal to that of the mountain grade road and until all brake cleaning points give the attention to this work as called for by A. R. A. instructions and rules. Excessive retained duty causes cracked and "brake burned" wheels, and for which the owning road is responsible.

"In Date" and cars for brake cleaning when on shop or repair tracks are to have, in addition to the other brake work, a test of retaining valve and piping and to come within specified limits for leakage.

Formerly this was a gage test, but in the 1925 rules prepared by the Bureau of Safety and a committee of the Mechanical Division of the American Railway Association, the gage test is made optional, though preferable (the last paragraph of interchange rule No. 60 makes a portion of these rules part of it). The alternative is rule No. 165 and reads:

"If the retaining valve and its pipe are not tested by a gage, as prescribed in rule 164, it must be tested by applying the brake with a 20 lb. reduction from not less than 70-lb. brake pipe pressure and when the tripple valve is released the retaining valve must hold the brake applied with force for 3 minutes at the end of which time the air must discharge at the retaining valve exhaust."

While the old rules making a gage test mandatory was rather burdensome, through the special and cumbersome apparatus required to connect and, where the gage connection was made at the retaining valve, through the awkward location to connect, yet without a gage test it cannot be known whether the pressure retained is approximately correct nor whether the blow-down rate is excessively in error.

To obtain the results sought with practically no difference in labor over the stipulated test with no gage it is recommended that each freight car be fitted with a 3/8-in. tee, located in the retaining valve pipe convenient for attaching a gage, not over 3 ft. from the triple valve, with the side opening pointed down and that the side opening be closed normally with a brass plug.

After the brake cylinder has been tested by connecting the gage directly to the triple valve exhaust port and then after the retaining valve pipe has been fully and properly connected this tee will permit of making the test of the retaining valve quickly and efficiently.

To this end we recommend that the A. R. A. rules be amended to require that such a tee be made the standard for all new freight cars and that a limited time, say two years, be set for equipping all old cars.

Referring to the changed rules for testing, as quoted earlier, it is believed that those who have given the retaining valve careful study and are really interested in obtaining good air brake service will regret that the gage test has been made optional.

However, so long as this remains, safety demands that the alternative test, No. 165, be amplified. As it stands, the test will pass a valve with the vent port entirely closed, certain to cause excessive holding power, with attendant likelihood of cracked, broken, flat and "brake burned" wheels.

Just what is meant by "the retaining valve must hold the brake applied with force for three minutes" might advantageously be defined. Some may consider this met if the brake cylinder piston has not returned to release position, yet a backward movement of 1 in. or 1 1/4 in. at the most will permit of easily moving the braking shoes on the wheels by a push on the end of a brake beam or prying lightly against a beam hanger. Such shoes pressure can hardly be considered as being "with force."

The addition should stipulate that it shall be known that, when the triple valve is released, there is a sufficiently free discharge at the vent port and that this discharge shall have ended in the three minutes, following which the handle is to be turned down and a farther discharge must then occur at the exhaust port.

But, even with such an addition there will be no check against the valve holding too much, as from an excessively strong spring, due to improper repairs or stretching the standard spring.

When we consider the ease of using a gage with the proposed tee, and the advantages of the gage in determining exactly what the retaining valve will do in rates of blow-down, closing pressures and in indicating existing leakage; also, that, if desired, it can be used after turning down the retaining valve handle to determine whether there is any restriction in the pipe, it will surely be very appealing for a return to the gage test exclusively.

This paper was contributed by the Northwestern Air Brake Club.

Modern Freight Train Handling

Hard and fast rules for train handling cannot be properly applied to country wide conditions, or even in a general sense to individual trains; much depends on maintenance of equipment, much on the original design and much on the judgment used in the actual operation of trains. Where the original installation of equipment is correctly made, the maintenance up to the proper standard

and the manipulation in competent hands, satisfactory operating results will be obtained.

Braking Trains up to 150 Cars, All Loads or All Empties, with Automatic Application, Practically Level Territory, Normal Traffic Conditions.—Your committee recommends that when making service stops, the throttle be gradually closed to between 1/2 and 1/4 of its working volume, and a brake pipe reduction of from 7 to 9 lb. be made as the initial reduction. As soon as the brakes have applied, which is indicated by the blow ceasing at the brake pipe exhaust, and the train slack has become adjusted, ease off to a drifting throttle.

Where the reduction made proves sufficient to complete the stop, a further reduction of from 7 to 9 lb. should be made when not over 40 ft. from the stop, in order to start the slack to run in at a time when it cannot run out again before the stop is completed. If this reduction is correctly made, the brake valve will be exhausting brake pipe air when the engine stops.

Should the initial reduction be insufficient to complete the stop, a further reduction of sufficient amount should be made. However, the final reduction as above outlined should be made when not over 40 ft. from the stop.

The throttle should be closed just before final reduction is made. When using sand in making stops, start its use before applying the brakes and continue until the stop is made.

The brake valve handle must never be moved to lap position and allowed to remain there just previous to making a service application, nor until after the initial brake pipe reduction has been made. This will avoid undesired quick action, and for the same reason, also avoid harsh slack action; reductions specified above should not be exceeded. Where excessive brake pipe leakage is present, make lighter reductions and use steam stufficient to keep train slack stretched during the entire stop.

When using the automatic brake to stop for water or coal, do not attempt a spot stop, but stop short and cut off the engine from the train. During the period the engine is cut off from the train, take advantage of the excess pressure feature to accumulate maximum main reservoir pressure to aid in releasing and recharging the train brakes.

Braking Train of 50 to 150 Cars Approximately Equally Divided as to Loads and Empties.—Loads Ahead.—We agree that if loads and empties could be alternated, ideal operating conditions would be approached. However, the necessary switching would create inexcusable train movement delay. Trains composed of loads ahead and empties behind can be satisfactorily operated under the above specified rules of braking, provided sufficient steam is used to keep the slack well stretched during brake action, and the locomotive brake is kept released.

Braking Trains of 50 to 150 Cars Approximately Equally Divided as to Loads and Empties.—Empties Ahead.—Your committee believes that harsh slack action in trains of such make-up is, under certain conditions, unavoidable, and recommends that the make-up of such trains be changed, switching from 2/3 to 3/4 of the empties behind the loads. The same braking rules as above specified, to be followed, particularly as to the extent of the brake pipe reductions made, the working of sufficient steam to prevent slack action, and keeping the locomotive brakes released.

Train Stops With Locomotive Brakes.—When making a drifting stop, or a slow down, on level territory, where traffic conditions permit, in the absence of rules to the contrary, the stop or slow down may be made with the locomotive brake. Due care must be used to avoid severe train slack action which causes severe shocks to draft rigging and also to avoid overheating tires. Under such conditions, water and coal stops may be made without detaching engine from train.

Releasing After Automatic Service Applications, Under the Above Stated Conditions.—Release must not be attempted when less than a total reduction of 15 lb. has been made. Assuming that the air compressor, the main reservoir, and the feed valve capacity are sufficient to supply the required volume of air to effect the release and that the brake pipe leakage is not excessive, objectionable overcharging of the head end will be avoided if during the release the brake valve handle is not left in release position longer than fifteen seconds. Use the "kick off" one or more times until the head brakes do not reapply.

When the brakes are applied on a train of fifty or more cars, moving at a speed of less than 15 miles an hour, they should be held on until the train is stopped. This does not apply to grade service when retaining valves are in use.

After the brakes have been released and the train started, avoided moving the brake valve handle from running position to release position, unless it is known that some brakes have reapplied. The unnecessary use of the "kick off" movement causes an overcharge and is thereby a prolific source of brakes creeping on, or reapplying and causing wheel damage.

Back-Up Movement.—When making a back-up movement with 30 cars or more, and it is desired to make a service stop, engineman will apply brakes lightly, using steam until a stop is made, keeping the engine brakes released. Where adverse grade conditions prevail to an extent where the running out of slack cannot be avoided and there is danger of the train breaking in two, the brake application should be made from the rear end of the train by a suitable back up hose arrangement, or a sufficient number of hand brakes should be applied on the cars farthest from the locomotive to prevent damage from harsh slack action.

Train Handling on Grades:—We assume that all railroads with heavy grades have their own rules, the result of years of experience, to govern the handling of trains.

Double Heading and Helper Service.—When double heading, the engineman on the second engine should always allow the train to be started by the engineman of the leading engine if possible, before he begins to work steam. Starting both engines at the same time will cause a severe shock if slack is bunched.

With the helper engine at the rear of a train, its engineman should be the first to use steam in starting, using the same care as he would if starting the train with an engine on the head end. The head engineman should start promptly and carefully when the slack has been pushed in by the helper engine or when it is evident that the helper engine has stalled.

In the absence of special rules governing backing movements on a grade, with helper engine on rear end of train—such as backing in, or backing out of a siding—the helper engine should be considered the lead engine and should operate the brakes. A full understanding must be had before the helper engine assumes the control of train movement, and before the head engine relinquishes the control by cutting out the brake valve. During such movements, care should be exercised to prevent an overcharge of the brakes on the rear end of train.

When double-heading, or when using a helper on the rear end of a train, except in cases as specified above, while governing backing movements, the brake valve on the second or helper engine, must be cut out from the brake pipe; this to give the lead engineman control of the brakes.

In no case will the second engine of a double header or a helper engine assist in charging the train during brake tests or during a train movement.

Air brakes must not be depended on to hold the train when a stop is made on a grade. Release the air brakes and hold the train with hand brakes. When ready to start, the hand brakes must not be released unless the air brakes are fully recharged.

Slacking.—When necessary to take slack in starting, endeavor to take either a foot or two, on the slack of the entire train. Apply the independent brake to hold the engine while reversing. On a grade where necessary to take the slack, sufficient hand brakes must be applied to prevent the rear end from running back and causing damage.

With a helper at the rear, the slack should be pushed forward until the helper is stalled and be held there. The lead engine will then bunch the slack from the head end against slack being held by the helper engine. Apply the independent brake on the lead engine while reversing it, then start the train carefully, on sand, to avoid slipping.

Thermal Brake Test.—The thermal or wheel temperature brake test is the most accurate method of determining brake efficiency. After descending a grade, the hotter the wheels the more braking was done, and any car that has cold wheels proves the inefficiency of the brakes on that car; as the braking force of a car is in proportion to its empty weight, the cars with the greatest empty weight in any particular train will have the highest wheel temperature where the brakes on all cars are in equally good condition.

The thermal test should be made where conditions favor, such as where stops are made to cool wheels, and cars with either cold or excessively hot wheels should be carded to indicate the brake condition.

General.—Your committee recommends for the avoidance of overheated wheels, stuck brakes and slid flat wheels, that a careful observance of the methods suggested herein for brake manipulation be strictly followed, particularly in the attempted release of brakes when they have been lightly applied. Under no conditions, after either a stop or a slow down has been made, should a release of brakes be attempted when a total brake pipe reduction of less than 15 lb. has been made.

The so-called "graduating off" of freight train brakes is often responsible for wheel damage, due to the brakes with the best holding power remaining applied, which forces them to assume the entire duty of train retardation, because the brakes with the least holding power will have released. In many cases the "kicking off" of some brakes in the train will not produce harsh slack action and this objectionable practice has received sanction in some localities. The safety of the wheels should be one of the governing factors of train brake operation, and your committee for this reason condemns the practice of the so-called "graduating off" of freight train brakes.

Trains Parting

If a train parts while in motion, the engineman must shut off steam immediately and place the brake valve handle in lap position, releasing with the independent brake, if necessary, to prevent the wheels from sliding.

Under no circumstances must a locomotive be reversed while power brakes are applied. After an emergency application occurs, from any cause, do not attempt to release the brakes until the train has stopped. Brakes so applied on long trains are difficult to release, and care should be exercised in the manipulation of the brake valve during release, and the trainmen should note particularly that the brake on each car has released.

Inspection en Route

When leaving a terminal or stations where the engine has been cut off, or where switching has been done, enginemen should maintain a speed of not to exceed eight miles an hour for a full train length. An inspector or trainman should be stationed on the ground at the head end of train and remain there while the entire train passes him and he will not permit the train to proceed unless all brakes are released. This rule also should apply at all inspection points and at coal and water stops.

At terminals where yard testing plants are used to charge train brakes, frequent checking to insure that correct testing pressure is maintained should be made. If an overcharge of train brakes has occurred, owing to too high testing plant pressure, the brake must be applied with sufficient reduction to bring the overcharge down to normal, before the road engine is coupled to the train.

At the terminals not equipped with yard testing plants, where the brake test is made from the engine, due care should be exercised to avoid overcharging the brakes during release by leaving the brake valve handle too long in release position. When releasing brakes at terminals, or during train movement, overcharging will be avoided by observing the rules for releasing.

On arrival at terminals, to aid the inspectors in making the incoming brake test, engineman should stretch the free slack out of train, and apply the brakes with a 25-lb. brake pipe reduction before the engine is cut off. Angle cocks should not be closed and air hose separated until engineman gives signal that brake pipe reduction is completed.

To avoid damage imposed by excessive strains due to pulling air hose apart, they should in all cases be uncoupled by hand. This rule should be carefully observed by trainmen at stations en route where the engine is uncoupled or switching is done. The failure to uncouple hose by hand is the most common cause for the increase of brake pipe leakage after departure from terminals.

Paper contributed by the St. Louis Air Brake Club.

Fuel Costs Increase Slightly

A statement prepared by the National Coal Association from the monthly reports of Class I railroads to the Interstate Commerce Commission, shows that the average cost of coal used by those railroads in locomotives in transportation train service during March was a little above the February figure. The averages for the different districts are as follows: Eastern District, $2.72; Southern District, $2.22; Western District, $2.93; entire United States, $2.65.

These averages indicate an increase of $0.03 per ton in the Eastern District, $0.01 per ton in the Southern District; $0.02 in the Western District, and $0.02 for the whole United States.

Compared with similar averages for March of 1925 there is a decrease of $0.14 per ton in the Eastern District; $0.19 in the Southern District; $0.18 in the Western District, and $0.17 for the whole country.

Northwestern Exhibits Oil-Electric

The Chicago and Northwestern Railroad recently received from the Schenectady works of the General Electric Company its first oil-electric locomotive. Although several of these locomotives have been placed in service by eastern roads, this is the first oil-electric to be operated by a railroad west of the Allegheny mountains. On May 3, the oil-electric was placed on exhibition at the Chicago & Northwestern terminal in Chicago, where it was visited by thousands of the public and interested railway men. The locomotive is 32 ft. 6 in. long, 10 ft. wide, 14 ft. 7 in. high, and weighs 60 tons. The starting tractive power is 36,000 lbs., at 30 per cent factor of adhesion.

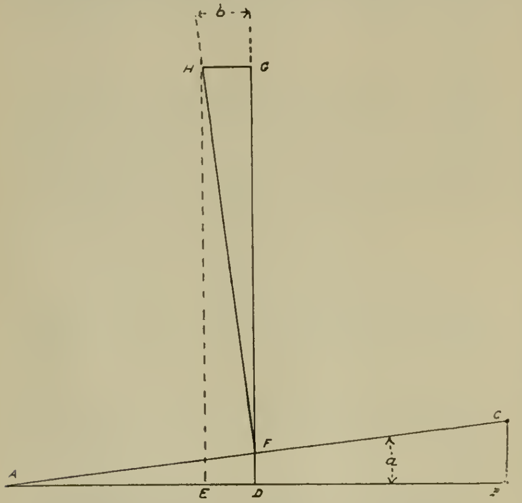
The Determination of Height of the Center of Gravity of Cars and Locomotives

By GEO. L. FOWLER

A few years ago in the course of an analysis for the determination of the causes of a serious railway accident, it became necessary to ascertain the height of the center of gravity of certain cars that were suspected of causing the accident by overturning.

The method used was that of a direct measurement and was so simple and apparent that, though it was original, it seemed improbable that it would not occur to anyone having such a determination to make.

Recently, however, attention has been called to the fact that it is common practice to calculate the height of the center of gravity of cars and locomotives instead of measuring it, hence this explanation of the simple method that was used, which is much more rapid and accurate than any calculation based upon the weights and relative locations of the several parts entering into the structure can possibly be. Take a car truck for example, it is composed of a number of parts of complicated and irregular shapes the determination of the location of where individual centers of gravity either by suspension of measurement would be a long and tedious process. And when it comes to the locomotive with the multitude of pieces entering into its running gear the difficulty of the problem is immeasureably increased, to which is added the complication of the position of the crank-pins, for it is evident that the center of gravity of the engine is higher with the two cranks in the upper quarters than when they are in the lower quarters.



Method of Determining Height of Center of Gravity

The method here set forth makes possible a direct measure of the weight of the center of gravity, accurately and with a minimum of simple calculation.

The principle of the method is that of tilting the vehicle on one side and determining the relation between the weight thus imposed on the lower wheels and the vehicle as a whole.

This principle will be understood by a reference to the accompanying diagram, in which A and B are the points of support on a level track; B C the amount that one side is raised. D G is drawn perpendicular to the center of the line A B and F H perpendicular to the center of the line A C. The angle H F C or b will then be equal to the angle B A C or a.

The vehicle is first weighed while standing on a track with both rails on the same level as at A and B, when, if the vehicle is symetrical one-half of the weight will be supported at A. One side is then raised to a height B C and the weight then resting on A determined.

The weight on the lower rail at A will then be to the weight on the higher point at C inversely as the horizontal distance between the center of gravity and the two rails or

Weight at A: weight at $B = B\ E : A\ B$

From this the displacement of the center of gravity from the center of the track, due to the tilting or the distance D E is determined.

The size of the angle of elevation a is obtained by dividing the amount of elevation B C by the distance A C between the points of wheel supports.

Then by dividing the lateral displacement of the center of gravity $D\ E = G\ H$ by the sine of the angle of elevation a we obtain the distance H F which will be the height of the center of gravity desired.

For example, suppose the distance between the centers of the railheads to be taken as 58.5 in. and that the lift BC is 7 in. then

$$\text{sine } a = \frac{7}{58.5} = .11966$$

Next suppose that the total weight of the car on the scales is 100,000 lbs. and that the weight on the lower rail, when the car is tilted, is 65,900 lbs.

Then

$65{,}900 : 34{,}100 = x : 58.5 - x$

or

$3{,}855{,}150 - 65{,}900\,x = 34{,}100\,x$

or

$100{,}000\,x = 3{,}855{,}150$

Then

$x = 38.55 +$ in.

in which

$x =$ the horizontal distance of the center of gravity from one of the rails.

The lateral displacement of the center of gravity GH is therefore,

$$38.55 - 29.25 = 9.35 \text{ in.}$$

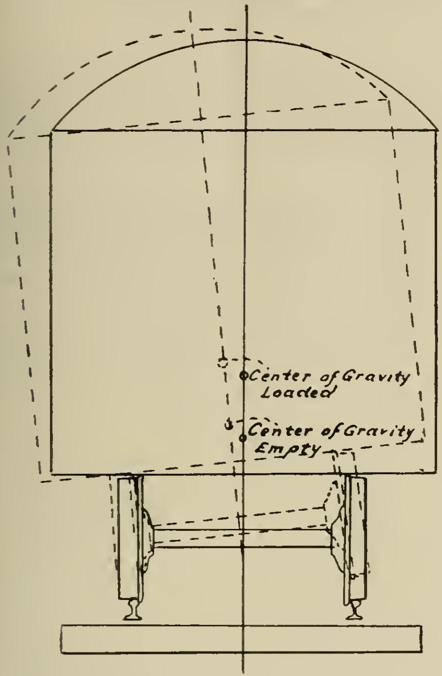
and

$$\frac{9.35}{\text{sine } a} = \frac{9.35}{.11966} = 78.14 \text{ in.}$$

In determining the center of gravity of cars or any spring-supported vehicle by this means care should be taken to so block the springs that they are inoperative. Else when the car is tilted the springs on the low side, owing to the extra weight that is put upon them, will yield more than the normal amount and thus cause an extra tilting of the car and with it an exaggeration of the lateral displacement of the center of gravity, which will result in an apparent increase of height that does not exist.

If the centers of gravity of tenders or locomotives are

to be determined the work should, first, be done with an empty tank or boiler. Then by weighing the vehicle while on a level track and filling it gradually with water, and weighing with the latter at different levels, the center of



Position of Centers of Gravity of Light and Loaded Car

gravity of the whole may be obtained by a calculation based upon the ratios between the empty boiler and tank and the centers of gravity of the several increments of water used in filling.

For example, suppose the height of the center of gravity of a tender empty is 4 ft. 6 in. and the height of the bottom of the tank is 4 ft.; that the weight of the tender empty is 80,000 and the area of the bottom of the tank 200 sq. ft. Then the weight of water one foot deep in the tank would be about 12,500 lbs. The center of gravity of this mass would be 4 ft. 6 in above the rail, so that that of the whole would not be changed, but the addition of another foot to the depth of the water would raise its center of gravity to 5 ft. above the rail and that of the whole vehicle to 4 ft. 7.43 in. because the centers of gravity of the vehicle and the water would be 6 in. apart and that of the combination of the two would be above that of the vehicle alone in the inverse ratio of 80,000 to 25,000, or 1.43 in.

The second diagram shows the position of the centers of gravity of the light and loaded car involved in the accident referred to in the opening paragraph. In this case the placing of 95 seated and standing passengers in the car raised its center of gravity about 17 in. thus very materially increasing its tendency to overturn.

The principle embodied in this method is practically the same as that used in the determination of the metacentric height of boats; that is the distance between the center of gravity of the boat itself and that of the water which it displaces. This determination is made by hanging a plumb line at the bow and stern and noting its position when the boat is on an even keel. Then weights are moved toward the rail, their distance from the center measured, together with the heel of the ship as shown by the angularity indicated by the plumb lines. In this case the calculation is made by the use of the cotangent, as its great length for the slight angle that the boat is careened is subject to a smaller percentage of error than either the sine or cosine.

It is believed that the use of this method will not only greatly lessen the time required for the determination but add to the accuracy of the results, besides giving the confidence of a certainty instead of the hazard of a guess that is more than liable to error.

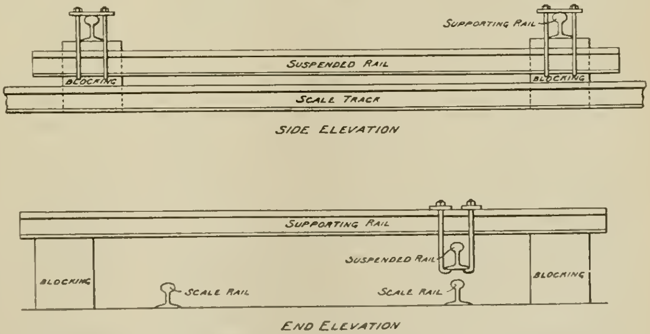
As for the practical method of doing the work it will vary with the facilities available. If portable scales that will weigh each wheel are at hand, and there are enough to assign one to each wheel of the car or engine, the work will be greatly simplified. The wheels can be weighed and those for the lower side left upon the scales, while the scale jacks can be used for raising the wheels upon the other side.

As these scale jacks rarely have a lift of more than $1\frac{1}{2}$ in. it will be well to lift and block and then lift again until the elevated wheels have been raised at least 6 in. Then the final weighing can be done on the lower scales.

If only ordinary track scales are available the work is a little more troublesome. In the case referred to, such was the case and the following method was followed:

The car was run upon the scales and weighed and then loaded with 95 passengers and weighed again. One side was then jacked up and held there while the supports for the elevated rail were put in place. These consisted of blocking put upon the ground outside of the scale platform and on this blocking a number of supporting rails were placed at the ends of each track. A rail was then suspended from these supporting rails by means of hook bolts passing through steel strips resting on the heads of the latter as shown in the engraving.

The car was then lowered so that its wheels rested upon



Blocking Arrangement for Determining Center of Gravity With Ordinary Track Scales

the suspended rail, whose height above the scale rail was then measured. This gave the height of elevation corresponding to *B C* of the diagram. The only weight then put upon the scales was that on the lower rail, which was taken and the height of the center of gravity determined as already indicated. Any other method of supporting the elevated wheels will answer provided it is independent of the scales.

Avoiding Train and Train Service Accidents

A Report to the Safety Section of the American Railway Association

By C. L. Lafountaine, General Safety Supervisor, Great Northern Railway

The records for the railroads for the United States show a total of 22,363 train accidents resulting in 219 fatalities and 1,491 injuries to employes and 41 fatalities and 2,125 passengers injured. This represents fourteen per cent of the total employe fatalities, one per cent of the injured, forty-one per cent of the fatalities to passengers and thirty-five per cent of the injuries.

The most frequent causes of train accidents are derailments and collisions.

Derailments resulted in 99 fatalities and 658 injuries to employes and 30 fatalities and 1,113 injuries to passengers—while collisions resulted in 85 fatalities and 720 injuries to employes and 11 fatalities and 987 injuries to passengers.

It will be seen, therefore, that these two causes were responsible for all except 35 of the fatal accidents to employes and 113 of the injuries—all of the fatal accidents to passengers and all except 25 of the injuries in train accidents.

Derailment Causes

Causes of derailments are shown under four headings:

Negligence of employes, 10 per cent of the accidents.

Defects in or failures of equipment, 47 per cent of the accidents.

Defects in or improper maintenance of way and structures, 26 per cent of the accidents.

Miscellaneous causes, 17 per cent of the accidents.

The most frequent causes of derailment under negligence of employes were on account of switches being set in wrong position, switches run through, running off derail and failures to latch or secure switch lever. This should impress us with the importance of watching switches more closely to see that they are properly set at all times, switch levers in propor position and main line switches are locked.

I wish to mention also under this heading the accidents due to the disregard of fixed signals. While these accidents are not so numerous as the once previously mentioned, they are of a more serious nature, resulting in 5 fatalities and 43 injuries to employes and 312 injuries to passengers.

The two outstanding causes of derailments, due to defect in, or failure of equipment, are arch bars, bolts, etc., bent, broken or other failure and cast iron wheels broken, overheating and other causes, many of which could be eliminated by more frequent or more efficient inspection, thereby correcting the condition before it becomes dangerous.

The most prevalent causes of derailments due to improper maintenance of way and structures, are first: insufficient, excessive or uneven super-elevation of track and improper alignment and surface of track, which accounts for nearly ten per cent of the derailments. This condition is brought about by failure of the men assigned to this work to see that it is properly taken care of. Broken rails are second in importance. This, however, is a condition which we find difficult to detect, even by careful inspection, once the rail is laid in the track. The solution seems to lie in the use of better material and rolling of the rails at the mills. Third in importance is rails spreading because of joints loosely or improperly bolted; another condition brought about by improper supervision and maintenance.

The miscellaneous causes comprise 73 different headings, under which the accidents are quite evenly divided, resulting in 2,522 derailments, causing 79 fatalities and injuring 295 employes, and 4 fatalities and 429 injuries to passengers, which indicates they are deserving of careful study.

Collisions resulted in 5,166 accidents, resulting in 99 fatalities to employes and injuries 821 and 11 fatalities to passengers and injuries 987 which represents five per cent of the total employes killed and half of one per cent of those injured, and seven per cent of the passengers killed and sixteen per cent of those injured.

The causes of collisions are shown under four headings, the same as derailments. The first, negligence of employes, caused 4,488 accidents or eighty-six per cent of the total collisions, resulting in 85 fatalities and 685 injuries to employes and 11 fatalities and 873 injuries to passengers.

While I believe too much stress has been placed on collision accidents, especially by the press, I feel it is important here to impress upon you the fact that these accidents are nearly all due to negligence of the employe; and the personnel of your train, engine and yardmen is the factor to be considered in eliminatig these accidents.

We find that sixty per cent of the total number of collisions is due to switching accidents, the principal causes being failure to properly control cars or secure them with hand brakes, switches set in the wrong position, improper handling of cars or locomotives in switching or coupling, failure to keep proper lookout, absence of a man on front of leading car being pushed and failure of parties supervising work to see that it is done properly.

Second in importance, so far as injuries are concerned, are head-on collisions and third rear-end collisions, the two resulting in 53 fatalities and 342 injuries to employes and 10 fatalities and 847 injuries to passengers, principally due to improper train flagging, disregarding fixed signals, mishandling of train orders, failure to run with propor caution in yard limits and excessive speed in violation of orders.

It is encouraging that we have had a decrease of over fifty percent in the number of train accidents caused by collisions and over thirty-five per cent in the number caused by derailments compared with the record made five years previously. It is further of interest that the decreases have been very uniform for each of the four causes shown. The largest decrease, however, was in accidents due to defects in or failure of equipment. Under this one cause we show a decrease of sixty per cent in the number of collisions and forty per cent in the number of derailments.

Under this heading we find that we had 46,829 accidents resulting in 1,027 fatalities and 30,910 injuries to employes and 108 fatalities and 3,229 injuries to passengers. This is sixty-eight per cent of the total fatalities to employes and twenty-three per cent of the total injuries and seventy per cent of the total fatalities to passengers and fifty-three per cent of the total injuries. From this it will be noted that train service accidents are more than twice as frequent as train accidents and naturally result in a much larger number of fatal accidents and injuries.

The causes for train service accidents are grouped

under ten headings. The most frequent cause of fatal accidents to employes is due to being struck or run over by cars or engines, other than at highway grade crossings. This one cause alone resulted in 388 fatalities to employes, over thirty-seven per cent of the total employes killed in train service accidents. Under this cause we also find 25 passengers were killed and 59 injured. From a careful study of this cause of accidents, we find that they are due, with few exceptions, to the failure on the part of those concerned to exercise reasonable care and caution. It would have required only a little thought and effort on the part of those injured to eliminate this large number of injuries.

Second in importance are accidents due to coupling or uncoupling locomotives or cars. Here we find 72 fatal accidents to employes and 1,592 injuries. There has been so much said and written about accidents due to this cause, that it would appear to be only a repetition to say more on the subject, but I know from my own personal experience in yard and train service that with the modern coupling and uncoupling devices with which all cars and locomotives are equipped at the present time, there is absolutely no justification for this large toll in death and injury. The large percentage of them is not only due to violation of operating rules, but they are the result of reckless and careless practices which the men have acquired and to which they have become so accustomed that they do their work in this manner without realizing the dangerous chances they are taking.

The most frequent causes of injuries to employes, and third in importance so far as fatal accidents are concerned, are due to getting on and off cars or locomotives. These causes resulted in 62 fatalities and 6,564 injuries to employes.

We know there is an element of danger in getting on or off cars and engines, especially while moving, and I appreciate many of the accidents shown under this heading occurred when every reasonable care was exercised on the part of the employe. We further know that a large percentage of them could have been avoided by doing only what common sense and good judgment would have suggested and which experience has taught to many. This cause also resulted in 61 fatalities and 1,304 injuries to passengers; seventy per cent of the total fatalities and over fifty-three per cent of the total injuries in train service accidents.

This alone is of sufficient importance to justify a careful study on the part of each safety officer as well as the management of his road, to see that our present method of loading and unloading passengers is as safe as it is possible to make it, and if so that the employes whose duties require them to handle this work, perform this service with maximum efficiency.

Next in importance is operating locomotives, resulting in 5,878 accidents causing 20 fatalities and 5,877 injuries to employes. Falling because of failure to secure a safe foothold or hand hold caused twenty per cent of these injuries, including half the fatal accidents. Alert attention on the part of the individual will be found the greatest factor in preventing such accidents.

Failure of mechanical devices either through defect or faulty operation, while shaking grates, dumping ash pans, operating reverse levers, etc., caused 551 injuries and the failure to give warning, or use proper care before moving locomotives caused injury to 351 employes.

Now that I have told you about the number of accidents and some of the principal causes, the number of employes and passengers killed and injured in train service accidents, I should like to leave this though with you:

In order to make a substantial reduction in this class of accidents, it is essential that our railroad be in good physical condition with a safe roadbed and rolling stock.

But this is not so important as are the employes who man it. The adequate training of new men is a vital element in accident prevention. Many men have entered the railroad service with sufficient ability to become efficient and safe railroad men, but they have caused many an accident through the failure of those charged with the duty of informing them properly to advise and train them when they were learning the work. The most efficient method of performing work will always be found to be the safest and I should recommend that young men entering the service, be given the best possible training. If this is done, I am confident we shall be able to show even a larger reduction in train and and train service accidents in the future.

The Elimination and Protection of Grade Crossings

The National Conference on Street and Highway Safety, in its final report, has this to say on the subject of eliminating and protecting grade crossings:

Elimination of grade crossings, either by relocation of highways or rail lines or by grade separation which constitutes the only perfect solution of the problem, should be carried on under a proper program, first eliminating the most dangerous crossings on thoroughfares carrying heavy traffic, and with due recognition of the enormous costs involved which, if elimination were attempted on a wholesale scale, would impose an excessive financial burden resting in the last analysis upon the public. The program should have due regard to the relative costs and advantages of grade crossings elimination and other methods of protection, and should be given the most thorough joint consideration by proper authority. In laying out new highways or railroads, or relocating existing highways or railroads, grade crossings should be avoided or eliminated whenever feasible. In eliminating grade crossings narrow or obstructed underpasses and sharp turns in the approaches thereto should be avoided. Authority to order grade separations or proper protection at grade crossings should be vested in the commission having jurisdiction over the railways and this commission should also determine the proper division of costs between the railroads and the public. The state highway department or other highway authorities should plan the improvement and initiate the proceedings for all highways under its jurisdiction. Time is an essential element and a prompt decision should be provided for in the law.

Railroad crossings remaining at grade should be safeguarded in every reasonable way. Standard warning signs and pavement markings should be used to mark clearly the approaches to all public railroad crossings. Where the volume of traffic requires it additional protection should be afforded by the use of flagmen, gates or approved electric or mechanical devices standardized as far as practicable. So far as possible a clear view along the track in both directions from both sides thereof should be maintained. The placing of railroad cars near unprotected grade crossings so that the view is thereby obstructed should be discouraged. Sharp curves, abrupt changes of grade, roughness in the pavement, or other conditions at or near the tracks which tend to divert the attention of the motorist should be avoided. Properly designated state commissions should be empowered to designate dangerous grade crossings at which motorists must stop.

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The New Union Pacific Locomotive

If, in these times of rapid changes and spectacular developments we were in a mental attitude to be astonished at any thing, it is probable that there would be a universal astonishment among the railroad fraternity at the new engine built by the American Locomotive Co. for the Union Pacific System and illustrated and described in another column of this issue.

And yet, in a way it is but the outcome of a natural development. The Rocket had but one pair of drivers though it did have a rigid wheel base formed by two pair of wheels and there is little difference, probably, whether all the wheels of a rigid wheel base are drivers or a portion of their mere carrying wheels.

Then we have increased the number of driving wheels gradually, through the course of a century with occasional sporadic jumps ahead, though these sporadic developments have usually been short lived, until we have come to regard six and eight pair of drivers as a matter of course in the Mallet design. But this is in the form of two independent engines. We accepted the 2-10-2 wheel arrangement almost as a matter of course, and now comes the 4-12-2, without creating more than a ripple, other than that such a design cannot be brought out without causing railroad officials to prick up their ears to learn as to the road performances of an engine that promises not only to be a simplification of the Mallet design but an improvement in the work performed.

We call it a six-coupled rigid wheel base, and with the 67 in. wheels used, this means a total wheel base of 30 ft. 8 in. The spacing between the five rear pair of drivers is brought down to 70 inches which leaves about as little clearance as is admissible between the flanges of wheels 67 in. in diameter at the treads. Then there is a gap of 88 in. between the centers of the two front wheels to allow for the introduction of the link and the guide yoke with its attachments.

As a matter of fact there is not a 30 ft. 8 in. rigid wheel base, but one that can scarcely be called 17 ft. 6 in. long, this because of the large amount of lateral play given to the journal boxes of the front and rear drivers. This is made possible by the ingenious retrieving device used to bring those wheels back into alinement with the others when they have been moved laterally in passing over a curve.

This drawing of the wheels back into alinement is probably a very good thing, though as a matter of fact, it has been pretty definitely proven that an excessive amount of lateral play in the driving boxes, actually reduces the truck stresses, on a straight track, imposed by an engine having such play as compared with one keyed up to the regulation 3/8 in.

The side rods would seem to offer a problem difficult of solution with such a long driving wheel base; but, unmechanical, as these long rods would seem to be, the fact is they make no trouble. A number of years ago, in a long driving wheel base design, rods were made having spherical joints instead of the simple knuckle pin, but those joints gave so much trouble that they were soon abandoned.

Again on our large engines main crankpin stresses have become a serious problem, and heating, especially on new engines, is frequently a source of considerable trouble. It is reasonably expected that the use of three cylinders will materially reduce this. Of course the main crank pin is relieved of a direct main rod thrust, by the amount of the work done by the central cylinder, and, in a general way, it might be expected that the two outside cylinders would care for the rotating of the four rear pair of drivers and the center cylinder for the two forward pair, but this can hardly occur throughout a whole revolution, for, at certain points of the cranks, some of the outside cylinders stresses must be carried forward and at others some of the center cylinders stresses must be carried back of the main crank pins. This is an interesting analysis that will probably be made public later.

But when all is said and done "the proof of the pudding is in the eating thereof," and the proof of the probable success of this engine is in the running thereof. So that with a credit of nearly fifty miles an hour in speed a high tractive effort and the easy negotiation of sixteen degree curves the remainder must be left to the general economic efficiency for the determination of which some time must be allowed.

Efficiency and Economy from Improved Methods on the Baltimore & Ohio Railroad

No one questions the fact that in recent years railways as a whole have been sorely pressed for the necessary capital to provide needed improvements and betterments to their physical plant. While there have been cases in which the lack of necessary facilities have affected the earning power or operating efficiency of some roads as a complete transportation unit, at the same time there have been other cases wherein large expenditures have been made that were not absolutely essential to economic operation of the properties, and this applies particularly

to facilities for the maintenance of rolling equipment.

In some instances, elaborate and expensive shops and roundhouses have been constructed and equipped at a cost of from one to three million dollars that were badly needed and should have been provided ten of more years before. With others, a very small percentage of the amount expended, if intelligently applied, in the improvement of existing shops and with a competent shop organization, the desired results could have been attained.

It was especially gratifying to recently inspect the main locomotive shops of one of our large trunk lines in which a higher degree of shop output and efficiency is obtained with a minimum expenditure for new or improved tools and machinery and practically nothing for new buildings and permanent structures. We refer to the Mt. Clare shops of the Baltimore & Ohio Railroad, which we had the privilege of investigating recently through the courtesy of G. H. Emerson, Chief of Motive Power of that road, and which revealed so many features that make for economy and efficiency that we hope to make them the subjects of future articles in the pages of this paper.

Shops Are Eighty Years Old

The purpose at this time is not to go into details of various angles of shop design, equipment, tools, etc., which could be dealt upon in some length, but to drive home the fact that here is one of our leading trunk lines with something like 2,596 locomotives, gross earnings of $224,318,794 and which expended last year more than $48,000,000 in maintenance and equipment. Yet, their main locomotive shops, where they not only make heavy classified repairs, but, are building new locomotives was built in 1845 or over eighty years ago. The principal dimensions of these shops, such as length, width, height or headroom, etc., are precisely as they were when built eighty years ago, although the size of locomotives have increased many times in that period. By the periodic installations of the necessary number of improved tools and machinery and a competent shop organization, the output and degree of economy is equal to, if not ahead of, the shops of some of the carriers that discarded as out of date and antiquated shops that were built thirty or forty years after the Mt. Clare shops of the Baltimore & Ohio.

Increased Output

The output and classified repairs has been increased from 1½ to 3 engines per day or about 900 per year, the heavy or class two repairs frequently being as high as thirty-five or forty new fireboxes per month. It is expected that with the installation of improved machinery and a slight increase of working force, the output of these shops will be increased to 4 engines per day or more than 1,100 per year.

The organization of the working forces and the systemizing of the work were the two main features in this improved condition.

What may seem strange to many shopmen is the practice of stripping all locomotives on tracks outside and adjacent to the shop itself, so that the shops are used only for repair and construction work. Then the machine work is so routed that as the engine is moved to its location or position on the erecting tracks, the finished parts are delivered at that point for assembly with a minimum expenditure of time, labor, and other costs. The finished unit comes out for service tests and is actually back in revenue producing service in a much shorter period of time and a correspondingly less cost per unit of repair than is the case with many shops of comparatively recent construction that have cost several million dollars.

There are other important factors in both operation and maintenance of locomotives which is is hoped will have reached a stage of development in the near future to permit their presentation in a future issue of this paper.

Strange Things Happen on Railways

Those who have had to do with railways or railway men over any considerable period of time can recall numerous instances in their own personal experience, or of stories narrated by others, of accidents or happenings that in some instances seemed almost if not quite impossible.

Doubtless many of these stories were true, while with some it was necessary to provide more than the proverbial "few grains of salt" in order to swallow them.

Drawing slightly on our memory, we recall the story of a freight train leaving one station with a given number of cars, and after passing at high speed over a very crooked stretch of track in a mountainous country, arrived at another station with two cars less in the train. Question: Where were the two missing cars and how did this happen? What might be considered a companion to this story is the one with respect to a passenger train which on approaching a regular station stop, the whistle having been sounded by the engineer, was suddenly subjected to quite a jar or shock accompanied by a loud report as of that of an explosion. The train however moved on and slightly past the station platform, where it stopped minus the locomotive. Question: Where was the missing locomotive and how did this happen?

We can then pass by quite a supply of stories such as that of the freight conductor who among many others was being pinned down in a loss and damage claim against the company as to exact condition of a certain freight car that he, as conductor, had handled. In order to make out an unshakeable alibi for himself he made affidavit that in the particular case he had sensed a very valuable shipment and to make sure of its proper care and protection he had personally inspected the car, and noted particularly that the seals were intact on both side and end doors, and that none of them showed any evidence of having been tampered with. We may draw on our imagination as to the degree of embarrassment of our Sir Gallihad conductor, when informed from headquarters that the car in question was "a flat car."

Coming to the more serious and possible things that some claim may and do at times occur, we can pass by such commonplace incidents as a locomotive casting or throwing a tire when at high speed and continuing right along for six or eight miles. At a regular stop the engineer discovered the loss by accident.

Cracked cylinders and cylinder saddles is and has been one of the most interesting, perplexing, and expensive features of locomotive design, construction and maintenance that has occupied the minds of the foremost engineers and founders in this country. The various methods employed to either prevent failure from these causes or to repair defects and thus continue engines in service call for much favorable comment and praise, yet we still have this all important problem of cylinder failures to cope with.

To attempt to enumerate the number of cases in which locomotives were held in roundhouses or put in back shops for repairs on account of cracked cylinders or cylinder saddles, would simply be impossible as it seems to be a disease peculiar to the species.

In all our experience, we have known of only one case of a cylinder actually dropping off of a locomotive while the engine was pulling a heavy tonnage train at a speed of 8 to 10 miles per hour.

This was a large modern Santa Fe type engine with

cylinders 29 x 32, weight about 360,000 and tractive power of about 75,000 lbs. Total weight of engine and tender about 580,000 lbs.

We personally inspected the broken parts of this cylinder and cylinder saddle, also the broken, bent and twisted side and main rods and therefore speak from personal knowledge of this most extraordinary and unusual accident.

The Oil-Electric Locomotive

By E. H. Outerbridge

There is perhaps no other single factor in industrial life throughout the world today so much in men's minds, so important and potentially so beneficial in its results as economy in productive effort. This is true whether it be individual or collective effort. The Chief Executive of a nation must study and develop the most economic use of his faculties and his time to meet the complex duties that he is called upon to perform; governments, whether national, state or municipal, can only be beneficent if a constant increase in efficiency and economy in cost obtains; the Chief Executive in any great administrative capacity can only preserve his health, strength and efficiency by a scientific arrangement and economy of his effort; manufacturing industries can only be profitable and survive to the degree that true scientific economy permeates all their operations.

It is a well-known axiom that capital is created only out of savings and it is increasingly true that profits and prosperity are dependent upon a continuous development of economy in productive effort, whether it be in the unit of man-power, of machine work or of administration.

There is perhaps no other single field in which this principle is as vital as in the production of power. Superpower organization has become a topic of almost daily comment in the public press and great strides towards its accomplishment have already been made. The vision and courage of men bring these things to pass, but economic law and necessity is the underlying force which spurs men to invention and accomplishment and gives the owners of capital the confidence to employ it in such developments.

There is perhaps no field in the use of power as important to the life and progress of humanity as the power employed in transportation, and of all forms of transportation the one of most vital importance in the United States, because of the extent of territory and its industrial development, is railroad transportation. There is, therefore, no field in the use of power where economy in its production is of such vital importance to the whole nation as economy in railroad power.

There is no abler body of men in the United States than the trained railroad executives who in their several departments have specialized in every element of economy that enters into transportation operations and their accomplishments are witnessed by not only the most extensive railroad systems in the world, but by transportation costs and charges per ton mile—the lowest in the world.

For a number of years past much has been heard in the marine field of a new form of power which has been rapidly growing and supplanting the former types of reciprocating and the later types of turbine steam engines. I refer to the well-known Diesel type of oil burning engine.

In still more recent times, within only the past few years, invention has made it possible to build the oil-burning engine of much lighter weight per horsepower and therefore of less cost than formerly, and through the skill, energy, invention and courage of three associated companies this principle has now been successfully applied in the development of what is known as the oil-electric locomotive.

It is not my purpose and I am not qualified to enter into any technical description of this latest product of invention and science. Up to the limit of size and power so far produced demonstrations have already been given which have so convinced the best experts in railroad operation of its economy and usefulness for certain fields and character of employment that numbers of these engines have already been ordered. It is always ready to go, no time is required to be lost in getting up steam, no waste in blowing off or in banking fires. If its development in higher power units than as yet produced gives equally favorable results for long distance hauls, it will challenge the attention of railroad operating men wherever the steam locomotive is now the main dependence.

If, as I believe, the draught efficiency of this engine per unit cost of fuel per ton moved greatly exceeds that of the steam locomotive, it would seem as if the oil-electric engine had the potential future of supplanting some of the present type of steam locomotives.

There is, however, on the other side of this question an important consideration which may place some limitation upon the future of this invention. That question is the quantity and permanency of the supply of fuel oil if a vast and rapid increase in the use of the oil-electric engine should ensue, and the effect upon the price of oil of such increased demand. Judging from recent reports in the public press experts differ vastly in their estimates of the oil supply. Some insist that it is capable of great expansion and of supplying all possible needs for generations to come. Others state that in a few years the available quantities will begin to rapidly decline. With the enterprise of oil prospectors and operators it seems fair to assume that they will be discovering and developing new sources of supply as rapidly as it will be mechanically possible for the developers of the oil-electric engine to produce them in sufficient quantities to seriously affect the oil situation.

Colorado Railroads Go Into Bus Business

Both the Colorado & Southern and the Denver & Rio Grande Western railroads will establish motor bus lines to supplement their rail service. The railroads at first opposed the granting of permits to bus companies serving their territory, but finally decided to install their own systems.

The Denver & Interurban, owned by the Colorado & Southern, is operating buses between Denver and Boulder, and the Colorado & Southern and the Denver & Rio Grande Western have organized a company to operate between Denver, Colorado Springs and Pueblo. Application for a permit is pending. This service is expected to extend to the northern part of the state by purchase of existing lines.

Shipment of Locomotives in the First Quarter

The department of commerce announces that March shipments of railroad locomotives from the principal manufacturing plants, based on reports received from the individual establishments, totaled 162 locomotives as compared with 163 in February, and 117 in March, 1925. Four hundred and forty-six locomotives were shipped the first three months of this year, as compared with 303 for the first three months of 1925. Of the 446 locomotives shipped this year, 387 were domestic and 59 foreign shipments. The domestic shipments consisted of 343 steam and 44 electric locomotives, and the foreign shipments were made up of 56 steam and 3 electric locomotives.

The Centenary of the New York Central

Meeting at Albany, Schenectady and New York on Anniversary of Granting of Mohawk & Hudson Charter

In celebration of the 100th anniversary of the granting of the charter to the Mohawk & Hudson Railroad on April 17, impressive ceremonies were held in Albany, Schenectady and New York.

The Mohawk & Hudson was the first to be chartered and built of the railroad companies now constituting the New York Central System. It was one of the first railroads in America and the first to be operated in New York State.

Two special trains carrying officers of the company left New York for Albany where brief exercises were held including the unveiling of a commemorative bronze tablet in the passenger station. The trains then proceeded to Schenectady where similar exercises were held and a tablet was also unveiled.

The special trains were preceeded by what proved a popular feature of the event, a pageant of power which included types of locomotives from the DeWitt Clinton, the famous little wood-burner of the Mohawk & Hudson, to the latest types of New York Central motive power. During the Albany ceremonies the power pageant was on display on a track in the station and was viewed by thousands before the formal exercises began on the arrival of two special trains from New York, bearing prominent railroad officers and guests.

The seats on the DeWitt Clinton stage-coach cars were filled by a group of employes of the New York Central, and members of their families, gaily costumed in the garb of 100 years ago. They made a colorful picture.

The DeWitt Clinton train, with its historic engine and coaches, headed the pageant. Behind the diminutive first locomotive of a century ago were nine motive power units, each illustrative of the development of locomotive power since that time.

Noteworthy among the units lined up was the historic and famous engine "999," built expressly to haul the Empire State Express in 1893. The old DeWitt Clinton engine measures with its tender 23 ft. 9 in. in length, while at the last of the line of locomotives there was a freight engine, more than 97 feet long, or more than four times as long as the DeWitt Clinton engine.

Next in line behind the DeWitt Clinton was displayed a Forney type of engine, No. 1916, used in past years in suburban passenger service in New York City. This same type of locomotive was for a long time also used on the elevated system in New York City. No. 1916, representative of this type is but 35 ft. 5 in. in length and weighing 71½ tons.

The American type of locomotive popular in the early 90's for the hauling of passenger trains followed the Forney type, being represented by "999." The "999" is 58 ft. 7⅝ in. in length and weighs 107 tons.

Next in line was No. 836, an Atlantic type engine representative of the earlier designs of locomotives for fast passenger train service. This particular type of engine was built in 1906 and weighs 98 tons, with a length of 69 ft. 2½ in.

Then followed a Prairie type of locomotive brought from the New York Central Lines West, as a special exhibit. The engine displayed was No. 4690, built in 1903. The engine is 69 ft. 7¾ in. long and weighs 95⅗ tons and is used in fast passenger service.

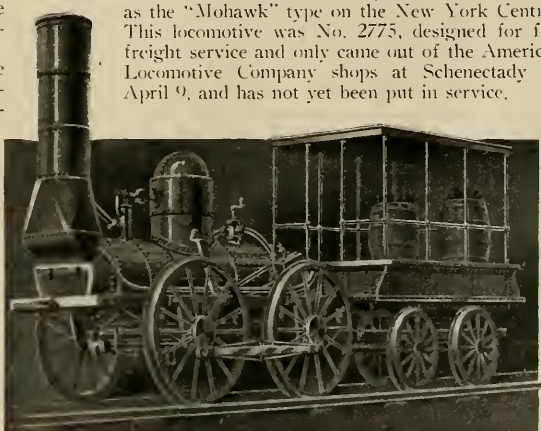
Behind these interesting developments of steam power plants on wheels came two electric locomotives. The first was No. 1251, 38 ft. long and weighing 100 tons, which has been designed for switching service on the Electric Division of the New York Central in the New York district.

Behind the switcher was No. 1162, used for passenger service and built in 1914. The length of this power plant in electric service is 56 ft. 10 in. Its weight is 132½ tons. This class of locomotive is used in moving all fast passenger trains between Grand Central Terminal and Harmon, N. Y.

Following was No. 3269, a Pacific type of locomotive. This type of locomotive handles the Twentieth Century Limited and all the New York Central Lines fast trains. The one on view was 78 ft. 2½ in. long and weighed 141 tons, and was built five years ago in 1921.

A Mikado type of locomotive, designed for heavy freight service, was next exhibited. This engine No. 356, was built in 1914, 12 years ago, weighs 167½ tons, is 81 ft. 9¾ in. in length, and is noted for its ability to handle heavy work at considerable speed on unusual grades.

Last in line on display was the latest developed freight locomotive of the New York Central Lines. The type is of the 2-10-2 wheel arrangement and is known as the "Mohawk" type on the New York Central. This locomotive was No. 2775, designed for fast freight service and only came out of the American Locomotive Company shops at Schenectady on April 9, and has not yet been put in service.



Original "De Witt Clinton" Locomotive of the Mowhawk & Hudson Railroad

It measures 97 ft. 1¾ in. over all, and weighs 181¼ tons, or 25 times the weight of the DeWitt Clinton engine and tender of 1831.

After the ceremonies at Albany, the power pageant moved to Schenectady, where many additional thousands viewed it during the afternoon.

Following the ceremonies at Schenectady, where George W. Featherstonhaugh, grandson of the founder of the Mohawk & Hudson Railroad, was a speaker, the two special trains returned to New York over the West Shore Railroad, through the classification yards at Selkirk and thence across the new Alfred H. Smith Memorial

Bridge over the Hudson, part of the New York Central's $25,000,000 "Castleton Cut-off" improvement.

The anniversary ceremonies reached their climax in the evening with a centennial dinner in the grand ball room of the Waldorf-Astoria, attended by almost a thousand persons, including railroad executives of all the principal lines, financiers and men of national importance in many professions and industries, as well as in public life.

President P. E. Crowley, of the New York Central Lines, who presided as toastmaster; Hon. Chauncey M. Depew, Chairman of the Board of Directors of the New York Central; Dr. Arthur T. Hadley, President Emeritus of Yale University; United States Senator Royal S. Copeland, of New York, and Arthur J. Hilly, Assistant Corporation Counsel, City of New York, Bishop William T. Manning, of the Protestant Episcopal Church, New York City, pronounced the invocation.

The speeches of President Crowley and Ex-Senator Depew were broadcasted over the radio by Stations WJZ and WGY.

In his address President Crowley reviewed the history of the New York Central System and the influence of the general railroad record on the history of America; he emphasized the genius of two of the New York Central leaders, Commodore Cornelius Vanderbilt and his predecessor in office Alfred H. Smith.

In closing his remarks President Crowley said:

"If a railroad is efficiently to serve a growing country like ours, it must not only keep young, but grow stronger year after year. A railroad that is not growing is dying. Obsolescence will strangle it.

"To carry the great traffic of today with the equipment and facilities of only ten years ago would be impossible. And it would be just as impossible to carry the greater traffic of ten years hence with the present facilities and equipment.

"The railroads of the country, as a whole, have never been so well managed, so efficient, so responsive to the public needs as they are at the present time. It may be that some of our systems, great as they are now, will be greater. It may be that weaker roads will be strengthened by closer association with stronger ones, and that stronger ones, through that association, will become even more efficient. But the greatest factor today in the success of our railroads and their hope for the future lies in co-operation—co-operation between the managements and their employes, between the carriers and the public bodies by whom they are regulated, and, above all, co-operation between the railroads and the public they serve.

"A hundred years from now, when directors and officers of the New York Central and the leaders of American industry gather here in New York to celebrate the bicentennial of this railroad system, they will look back upon a hundred years of progress far more wonderful than that of these first hundred years which seem so great to us.

"No mortal in 1826 could have had the vision to see the achievements of this wonderful hundred years—the age of steam and electricity; of the telegraph, the telephone and the radio; of the electric generator, the electric motor and the internal combustion engine; of the automobile and the airplane; of the harnessing of the inexhaustible power resources of this earth for the advancement of civilization.

"And no one today can see behind the veil of the next hundred years. But of one thing I am confident, and that is that this country of ours will carry on to greater achievements, blazing the broad trail of scientific discovery and human progress."

Address of Chauncey M. Depew

In the course of his remarks Chauncey M. Depew, who has been chairman of the Board of Directors of the company for the past twenty-seven years, its president for thirteen years and connected with the New York Central staff for over sixty years said:

"We trace the New York Central from its first expansion from Albany to Schenectady, and then by natural growth extending its lines to Buffalo, and from Buffalo to Chicago and the West, then to Cincinnati and St. Louis in the southwest, then to the northwest into Canada, until today, with its feeders and associated companies, it has found the shores of the Pacific Ocean, and is competing with the great Panama Canal.

"When I first joined the New York Central it ran from New York to Albany, 140 miles, and from New York to Chatham, 128 miles. That constituted all of its mileage. The entire mileage of the country then was only 36,000 miles, and now it is nearly 300,000.

"I remember in the early days of expansion, not only of our own lines, but all others going from the Atlantic to the west, a statement that every mile of new railway brought into cultivation and production 100,000 acres of farming land, and it was a wonderful picture to see these new communities and happy homes rising like magic as the steel rails brought them out of the wilderness into participation with civilization and the prosperity of the country. The whole story of American development is a most marvelous, exciting and inspiring narrative, and is told by the conception, building and successful operation of the American railroads.

"Great as has been the growth of the New York Central, yet it is a remarkable fact that during the most of its existence it has been under the management and general control of one family. When in 1864 Commodore Vanderbilt quit river and ocean navigation, he declared that the future of the country was in railroads. It was wonderful foresight that enabled him to make this prediction. He bought the Harlem railroad and in a few years transformed it from bankruptcy into a prosperous line.

"The commodore was succeeded by his son, William H., who was a very able and successful railway executive. Through his sons and grandsons the New York Central is still a Vanderbilt corporation. The Vanderbilts have associated with them the ablest men in the country in their board of directors, and the best minds in America for business, finance and transportation.

"Commodore Vanderbilt was one of those rare geniuses who by their own natural equipment make themselves phenomenally successful in life and add enormously to the results and productivity of the country. He had a remarkable faculty in grasping the present situation and forecasting the future. He was one of the most remarkable products of American organization and American citizenship. He said little in conversation but absorbed the ideas and suggestions of others, and possessed a rare analytical power of discernment between what was wise and otherwise in the vast accumulation of advice which was flowing in upon him.

"It staggers the imagination when we think of this corporation beginning with a capitalization and property values at less than thirty millions of dollars, and that now its stupendous value is a billion and a quarter.

"As I look back over my associates in the board of directors during these sixty years, over the men of great ability and sterling character who have held important positions, I recall them all vividly and I feel that I have passed most of my life in this association, in this companionship and in this wonderful company, that it makes life in retrospect infinitely worth the living."

Low Capital Costs of U. S. Roads

For the Type of Railroad Constructed the Capital Per Mile is Lowest in the World

The railways of the United States are capitalized at a lower figure per mile of line, type of construction considered, than any of the railways of the world. This fact is disclosed by a survey just completed on the capital costs in various countries.

Capital costs per mile are lower than in the United States in some of the Asiatic countries, such as China, India and Siam, and in South Africa. However, labor costs are extremely low in all these countries and railway development impermanent. Norway and Sweden and some of the Australian states also present a low cost which is explained by a marked predominance of narrow gage mileage.

The lower capital per mile in the United States is accounted for in part by the construction of most of the trackage here before the founding of cities, the growth of population and the increased value of land. This is only a partial explanation, however, as in large measure railway construction in the United States has been carried on so efficiently, and on so large a scale, as to keep unit costs very low.

RAILWAY CAPITAL AND CAPITAL PER MILE FOR SOME OF THE PRINCIPLE COUNTRIES OF THE WORLD

Source: Official railway reports of the several countries.

	Year	Capital	Capital Per Mile
America:			
Canada	1924	$3,413,865,613	$85,216
United States	1924	[1]18,201,897,712	75,322
Europe:			
Great Britain	1924	5,640,536,087	277,463
Belgium[2]	1922	660,630,293	213,231
Bulgaria[2]	1923	71,887,289	51,510
Denmark[2]	1925	149,500,736	99,531
France	1924	6,017,178,824	316,693
France[2]	1924	1,334,202,461	237,259
Norway	1924	160,586,639	74,791
Sweden	1924	458,349,605	47,824
Asia:			
China[2]	1923	251,000,352	59,170
Japan[2]	1924	2,379,064,607	62,165
India[2]	1925	1,071,667,209	145,791
Siam[2]	1925	28,044,269	39,487
Africa:			
Union of South Africa[2]	1925	576,030,285	49,969
Australia:			
New South Wales[2]	1925	484,816,381	85,723
New Zealand[2]	1925	216,903,535	70,311
Queensland[2]	1925	252,629,597	41,321
South Australia[2]	1925	117,023,090	47,731
Victoria[2]	1925	329,652,286	73,518
Western Australia[2]	1925	98,878,131	26,448

[1]Net capitalization. [2]State railways.
All computations at the normal rate of exchange.

However, the capitalization of the American railways constitutes not merely the original cost of the construction of the lines, but includes also a substantial part of the cost of modernization. There have been large capital expenditures in recent years for the construction of tunnels, the reduction of curves and grades, the expansion of terminals, the building of improved shop facilities, and various other provisions for increasing the efficency of transportation. Besides these improvements there have been large purchases of the latest types of cars and locomotives.

In Canada and Australia somewhat similar conditions as to railroad construction have applied as in the United States. Developments in Australia and most sections of Canada are new, compared with the United States; consequently capital costs tend to be lower. In France, Germany, England, Japan and Switzerland, cities sprang up originally without relation to future railroad development. As a result, railroad construction has been most expensive in those countries.

The location of cities already in existence in each of those countries naturally controlled the location of the railways which inevitably led to less economical often roundabout construction and made it impracticable to follow the best, most direct or cheapest routes. Large-scale construction was also less the rule than in the United States.

H. G. Wells points out in his history of the world that the United States have erroneously accepted the railroads as a natural part of their growth. The railroads created rather than followed that growth. They came along just in time to release a westward flow of population and did in a few decades for the West what it had taken 200 years to accomplish for the East.

The accompanying table, prepared by the Bureau of Railway Economics, clearly indicates that the railways of this country are not burdened with the heavy capital costs carried by those in the more important countries of the world.

Improvements in Steel Castings

There was a time, which many can remember, when steel castings were a gamble pure and simple. When it was a question as to which would predominate, solid metal or blow-holes. This was so true that it was not an uncommon practice for engineers who were bold enough to use the metal, to calculate what the casting ought to weigh and then weigh it in order to estimate the proportion existing between blow-holes and solid metals. If the blow-holes seemed to be too preponderant the casting was rejected.

As for a straight, true casting, that was a thing not to be expected. In one case a set of rack castings that were made with a thin base for the purpose of increasing the probability of soundness, each piece was so warped and twisted that it was turned over to an expert saw hammerer to be straightened, which was done.

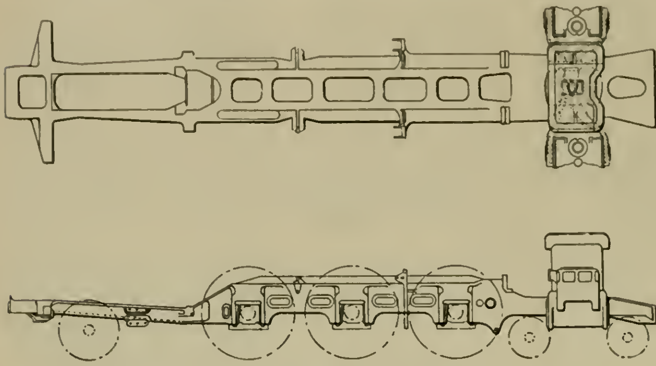
But the steel foundrymen gradually learned their trade, and the steel casting came into its own. It grew larger and heavier until, in time, it drove the old forged frame for locomotives almost out of existence. Then it became more and more ambitious until it appeared as a full fledged complete tender frame, where it has become such common practice as to cease to attract attention.

In all of this development, however, it has followed the precedent and requirement of foundry work from time out of mind, and avoided great differences of thickness in the same casting, and especially abrupt changes in thickness.

This rule holds for those late masterpieces of foundry work, the locomotive and tender frames. In one we have great thickness throughout nearly its whole extent and in the other, webs, flanges and ribs of a thin but practically uniform thickness. All so successfully cast that they have passed out of the category of the unusual.

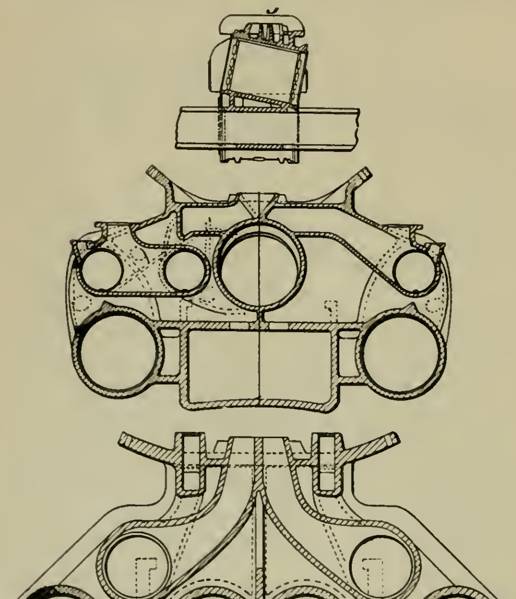
And now comes a proposed novelty that makes one catch his breath. It is nothing less than the frames, cross braces, saddle and cylinders of a locomotive cast in one piece. As far as information available is concerned,

the design, as yet, only exists on paper. But the fact that it has been patented by Mr. H. M. Pflager, vice-president of the Commonwealth Steel Co., and assigned to that company, leads to the assumption that the patent had not



Locomotive Frames, Cylinders and Deck all of Cast Steel in One Piece

been applied for, until the company was ready to assume the making of the article. Here we have all of the rules regarding the avoidance of varying thicknesses broken to pieces. There are the library frames with section that



Saddle, Frame and Cylinders of Locomotive of ast Steel in One Piece

must be 5 in. by 6 in. or more and holding them together the thin cross braces that cannot be more than an inch thick, with the same or even lesser thicknesses in the saddle and cylinders, to which must be added all the complications of cores for steam and other passages. Certainly the advent of the first casting along these lines will make a new era in locomotive construction. The saving in machine work expense as compared with the present designs will be very great, though new methods and possibly new machines will have to be brought out in order to do the work.

As it appears, the machining of the cylinders and saddle will be entirely done away with; and that of the frames for the fitting of these parts and the cross braces is saved, leaving little more than the fitting of the pedestals and some drilling.

The illustrations, which are reproduced from the patent drawings, show an arrangement of three and four-cylinder engines with the steam chests and saddle, indicating that the complexity of the casting has been studied.

The patent contains twenty-seven claims, which are, for the most part variants of the combination set forth at the start, of a locomotive bed including a steam cylinder formed gradually with said bed. The variants are combinations of more cylinders, the saddle, pedestals and braces.

Another patent issued at the same time to the same patentee and with the same assignment, for an engine truck with a booster engine support, would have attracted attention for the complexity of the casting called for, had it not been in such close juxtaposition to the one for frames and cylinders, which is such a notable advance over anything that has heretofore been produced as to dwarf anything else that may be placed beside it. Surely "the world do move" when we can compare a simple casting that was characterized as a "shelter for blowholes" with such a monster of weight and varying thicknesses as this will be when it appears in concrete form.

Gas-Electric Coach Service on the Chicago and Alton

Two 8-wheel gasoline-electric coaches have been delivered to the Chicago & Alton Railroad which are the first gasoline-electric equipment for highway operation to be purchased by a steam railroad. These coaches are of the Versare-Westinghouse design and are similar to the one described in the September, 1925, issue of Railway & Locomotive Engineering.

The Chicago & Alton will use them to supplement regular passenger service between Jacksonville, Illinois, and St. Louis, Mo., paralleling the secondary main line between Chicago and St. Louis which runs via Jacksonville. This line is 94 miles long and is over an excellent surfaced road.

The new coaches will operate on a schedule approximately the same as that now maintained by local passenger trains between these points. In addition to stops which will be made at all stations on the line the coaches will also pick up and discharge passengers at principal hotels and in business centers not adjacent to the stations, thus providing the same convenient service rendered by independent coach operators who have recently furnished keen competition to the railroad.

It is not known at this time just how much can be accomplished in reducing train service to offset the coach mileage so that for the time being the coach schedules

will be arranged to shorten the time that now elapses tween trains and thus to better the service now rendered the Alton's patrons.

For the present the coaches will be housed and maintained in the engine houses and shops now used exclusively by railroad equipment. Overhead expense incident to the establishment of this service will thus be kept at a minimum and the cost of the additional service, aside from interest on the investment, will be almost entirely confined to operating and maintenance costs. The rates of fare charged will be the same as the rail rates for the same distances.

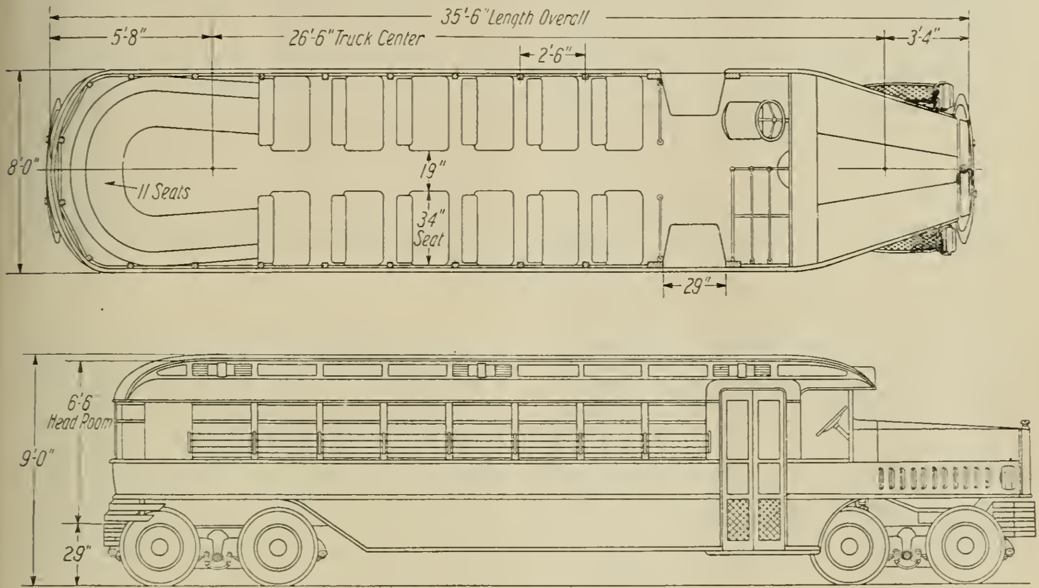
Some of the features of these coaches are truly remarkable. For example, although the coach is 35 ft. 6 in. in overall length it can be completely turned around, without backing, in a street only 40 feet wide. This is accomplished by means of a patented steering system which permits each wheel to run on a true circle, and the wheels of the rear truck follow almost identically in line with those of the forward truck.

This steering mechanism is a remarkable achievement and has made possible the development of an eight wheel vehicle. The eight wheels are used in the form of two complete and duplicate trucks which are in reality small chassis in themselves. These trucks being duplicate are interchangable for use either in the front or the rear of the vehicle.

The truck frames are of pressed steel and the front axles are a drop forged I section with integral pad at the center for the quadrant type of Ackerman steering. The knuckles are the reverse Elliott type fitted with thrust ball bearings. The wheel hubs are mounted on taper roller bearings.

The rear axles are double reduction of the internal gear type and have 20-in brake drums with internal expansion brakes that are of a special design, permitting the use of 20-inch disc wheels for pneumatics. Nine-inch diaphragm air brake chambers are mounted on a bracket at each wheel and actuate the brake cam levers, which may be independently adjusted for takeup without disturbing the air brake clevises or push rods.

There are four semi-elliptic underslung springs on each bogie truck. One end of each spring is pivoted in the spring hanger rigidly mounted at each corner of the bogie frame. Interposed between the pair of springs on each side is a ball bearing equalizer to which the springs are connected by means of shackles. These equalizers distribute the vehicle load equally to each wheel without depending on any spring deflection, providing the road incumbrance or depression is not greater than 5 inches.



Versare-Westinghouse, Gas-Electric Coach in Service of the Chicago & Alton Railroad

Government Ownership

"The United States will gain nothing and lose a great deal if it applies government ownership to its utilities," says Sir Henry Thornton, president, Canadian National Railways. "Canada got its state railways because private corporations operating them went bankrupt. Under certain circumstances public ownership is bound to fail, and under certain circumstances private ownership is bound to fail. Public ownership is bound to fail whenever politics enters into managements. Private ownership is bound to fail if the eyes of the management or of those who direct the management are more firmly fixed upon the stock market than the service the road is rendering.

"The tariffs on United States and Canadian roads are the lowest in the world and most of the managers are committed to the public interest. At the best, government ownership could do no more than subtract from the payments which the people now make to the railways, an amount which the railways now pay to the people through taxes. Therefore, with the highest possible form of government ownership it would seem that the United States could not do more than make some shifts in the incidence of taxation.

"There is nothing to gain and perhaps a great deal to lose—it is not worth even a gambling chance."

Snap Shots—By The Wanderer

There was a time when the apprentice was helpless in the hands of the master and when beating was one of the methods of inculcating the knowledge of the trade. Kipling illustrates this in his Captains Courageous where the mate takes the youngest in hand and by the effective means of a rope's end proceeds to teach him the ropes of the schooner. What the physical beating did for the apprentice the old-time superintendent or master mechanic applied in the way of tongue lashings to his subordinates. A rough tongue and a brutal manner coupled to natural ability were the essential requisites for such positions.

I once knew a prominent street railway superintendent who never spoke decently to any subordinate, and yet he seemed to succeed. I knew a railroad superintendent who was so ruthless in his treatment of his men, that his master mechanic, a man of a national reputation, was afraid to go across a railroad yard to see a new type of locomotive that was attracting nation-wide attention, lest the "old man," should send for him during the hour that he might be away. And great was the rejoicing when "the old man died."

Such cases, however, gradually disappeared, and in their place came the type of man that it a pleasure to think about. I know one example of the new type who, as far as I know, never issues an order. He always asks a subordinate if he "will be kind enough to do so-and-so." I do not know what would happen if the subordinate failed in the so-and-so, but, as I happen to be very well behind the scenes on that particular road, I do know that that non-order giving superintendent of equipment has the most loyal force that I have ever encountered.

So with the hazy past in my recollection and recent contact only with the later type of man, it was something of a shock the other day to run afoul of a real genuine old-fashioned type of blustering, abusing man in the saddle. His men jump when he calls and do what he tells them to do. But it is the jump of the recruit before a drill sergeant. It is the service begotten of the necessity of earning a livlihood and not of loyal fealty to the master. He gets no suggestions, no real assistance and never so much as an inference that some other way might be superior to the one he puts forth. It must be conceded that he is a man of great ability but one cannot help knowing that no one brain, however massive it may be can be capable of mastering all of the intricacies that arise in the solution of the many problems that occur in the routine of the management of the motive power of a great railroad. And this man carries his boorishness to a degree that was lacking in most of his old-time predecessors, for he is not even courteous to outsiders. In fact he is so notorious in this regard, that certain large supply men, with whom his road does business, will not go to see him.

Now a supply man is usually an interested witness, but more superintendents of motive power than a few owe much of the efficiency of their rolling stock to the suggestions and studies of supply men. And it is not good policy to cut off this source of suggestive knowledge.

Someone once said that all credit and praise was due to the self-made man and the greater the success the greater the credit. But after all, in the contemplation of whatever success he may have attained, one cannot help thinking of how much greater that success would have been and of how much more prominent the man would have been had he had the advantages of early systematic training.

So, when I saw the success that this man had attained; the smooth running of his department and the confidence that was placed in him, I could not help thinking of the far greater efficiency of it all, had he been more considerate of those about him, and so enlisted them in his service that they went to it not "as galley slaves at night scourged to their dungeons," but with an enthusiasm for the work and the master and with every effort strained, not to please for fear of the rod, but to add to the efficiency of the department. How much the road loses in dollars and cents by such a system is difficult to estimate, but it must be a vast sum because of the killing of initiative in all of those men who could help so much if they but dared. But above all this there looms a feeling of pity for the isolation that such a man has brought upon himself.

In my wanderings to and fro I pick up suggestions that I like to pass along. Now if it should ever be your fate to be called upon to design small hydraulic pumps, it will be well to bear in mind that many a pump with an ample clearance has given unending trouble throughout the whole period of its existence because it was so difficult to get the cylinder completely filled with water and the elasticity of the confined air was such that it would follow the plunger, by expansion on the suction stroke, and not rise, under compression, to a pressure sufficiently high to open the delivery valves, and so the plunger would run too and fro and not deliver a drop of water. For small pumps, one of the best remedies is to have the liquid run into the pump by gravity. This is not always possible, but, where it is, it is well to bear the fact in mind. Large pumps can be primed and vented, but for a small rapidly running plunger this may be difficult to accomplish and the gravity delivery is the best. Where the cylinder is horizontal, it is also well to have the suction on the bottom and the delivery on top as that will facilitate the freeing of the cylinder of entrained air. The valves should also always be vertical, as a horizontal or inclined valve is more apt to be troublesome and catch. The angle of the face with the center line should never be less than forty-five degrees and sixty degrees is better. An angle of forty-five degrees is just beyond the border line of sticking or not sticking. Less than forty-five degrees is rather apt to stick at times and that "at times" will certainly be at the period of greatest emergency.

Has it never occurred to you that those tight belts on that high-speed planing machine need a little relief occasionally? Of course I understand that you are a careful man and that, when the belts were put on, they were not stretched beyond their limit of elasticity and that they would go back to approximately their original lengths if they had but a chance. Though, if let alone, they will by and by assume a permanent stretch and be just a "leetle" loose. Not, perhaps, really loose enough to warrant you in taking them up, but so that, on a heavy cut, the heads lag and you must stop the feed until they begin to sing in the upper notes again. This is annoying, and all the more so since the difficulty can be easily remedied. Simply slip them off the pulleys at night and give them a chance to recover their normal length and you will have a belt that will have a constant tension for years.

The same results can be obtained for the belt coming

down from the shafting, by having the loose pulley just enough smaller than the tight to relieve the tension on the belt and still keep it in place. On woodworking machinery like moulding machines and surfaces this can be readily done as it is customary to run them for half a day at a time; but on iron working tools where there is a continual and repeated starting and stopping the jump pulley may not only not be a convenience but an absolute nuisance on account of the longer time required to do the shifting.

Some time ago, a well-known manufacturer turned out an article for which he expected an extensive sale. The experiments showed that the design was all that could be desired, and a careful examination suggested no improvements; but when the thing was built and put into the hard service for which it was intended, it failed to work. In short there was a steam chamber and in it a sleeve worked to and fro over an arbor. The fit was an easy one and the slightest push of the hand would do the work; but—and this "but" is of great importance—the sleeve was of cast iron and the arbor of brass. So, when the temperature of the two was raised by steam, their unequal expansion caused the brass to fill the sleeve and grip it so firmly that it could not be budged; merely a matter of the selection of materials; nothing more than a question of clearance; a trifling detail, but on it depended the working of the machine.

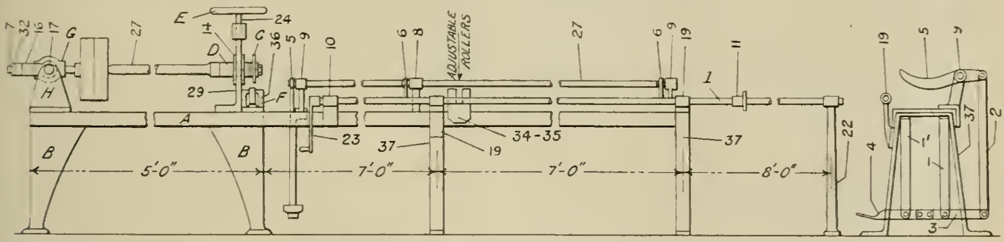
A Flue-Cutting Machine Designed and in Use on the Erie Railroad

The flue-cutting machine which is here shown in assembly and full detail is one that is in use in the Hornell, New York, shops of the Erie Railroad.

It consists of two parts; the shaft and running gear, which is shown at the left and the flue-holding portion at the right, both being held on a single body formed of a length of 12-inch channel, *A*, which has a length of 19 ft. At the left the channel is carried by the two cast iron legs *B*, which raise it to the height of 25 in. from the floor. At the right it is carried by the two legs *37*, which are made of ¾ in. by 3 in. flat steel and are bent to set into the two legs of the U-shaped casting *H*. It will be seen from this that the right hand end of the shaft can be moved up and down while turning about the centers that support its left hand end, and will always remain in alinement because of the trunnion-supported bearing at the right.

The shaft is driven by the tight and loose pulleys as shown.

The flue is handled at the right hand end of the machine. It is carried by two adjustable rollers held on 34 and 35 and is pushed on to the rollers in *F* beneath the



A Flue Cutting Machine Used on the Erie Railroad

in between the flanges of the channel, which, being inverted, presents a smooth flat upper surface for its whole length.

The cutter *C* is of the usual form of rotary cutter and is held by a nut and washer on the shaft *27*.

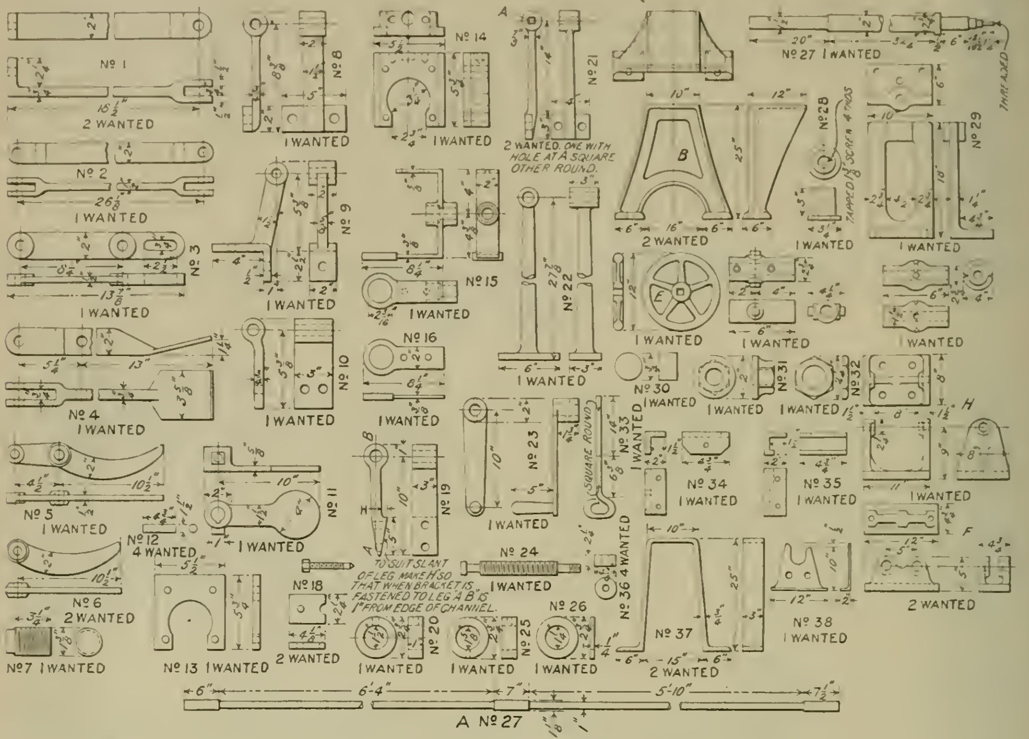
The shaft *27* at the cutter end, runs in a box *D* that is held on trunnions resting on the slide 14 to which the plate 13 is bolted. The two thus form a sort of crosshead that may be made to move up and down in the opening of the guide *29*. This movement is accomplished by means of the screw 24, whose collar at the left sets down in the counterbore of No 14, and is clamped there by the split plate 18. The boss at the upper end of *29* is threaded to receive the screw, which is turned by the hand-wheel. This provides for the raising and lowering of the cutter and thus feeding it into the flue.

While being cut the flue is supported by two rollers running on shafts set in the casting *F*, and which are immediately below the cutter.

At the left hand the shaft is carried by a box *G* that is supported by two center screws 17, that are screwed cutter. The length to which the flue is to be cut is regulated by the gauge 11, that is fastened to a length of 1-in. pipe 21 ft. long. This pipe is carried by the standard 22 and the brackets 19, 19 and 10 which are bolted to the flanges of the channel. At the left hand end of the pipe there is a handle 23 attached to it by which it can be turned in its supports. When not in use the gauge drops down out of the way, then after a flue has been pushed up under the cutter, the gauge is turned up so as to be in line with it. The end of the flue is brought back against it, when it will be in position for cutting.

After the flue has been cut it is lifted and thrown back by the trippers 5 and 6. These are attached to the shaft 27 and ordinarily lie below the flue that is being cut. The shaft itself is carried by the brackets 8 and 9. After the cutting is completed the shaft 27 is turned by means of the treadle 4, which raises the trippers so that they pick up the flue and allow it to roll back on to the skids and so out of the way. As it is necessary to rotate the shaft so as to raise the trippers, a compound leverage is used in connection with the treadle. The treadle 4 is pivotted at

the lower end of the rod 1' and connected at the inner end, by a pin and slot arrangement, to the lever 3 which is pivotted to the lower end of the rod 1 and at the outer end to the lower end of the connection 2 to the rear extension of the tripper 5. By this means, a downward movement of the treadle lifts the tripper and causes the flue to be removed from the machine.



Details of Flue Cutting Machine in Use on the Erie Railroad

New Equipment Installed and Condition of Motive Power and Freight Cars

During the first three months this year Class I railroads installed in service 21,363 freight cars, according to reports filed by the carriers with the Car service Division of the American Railway Association. This was a decrease of 22,790 cars compared with the number installed during the corresponding period last year and a decrease of 16,289 cars compared with the number installed during the corresponding period in 1924.

Of the total number placed in service during the first quarter of 1926, box cars numbered 9,582, coal cars 9,069 and refrigerator cars 1,206.

During the month of March alone, the railroads placed in service 8,546 freight cars including 3,934 box cars, 3,477 coal cars and 544 refrigerator cars.

Class I railroads on April 1 had 49,524 freight cars on order, an increase of 3,398 compared with the same date last year, but a decrease of 19,774 compared with the same date in 1924. Of the total number on order April 1 this year, box cars numbered 20,846, coal cars 20,237 and refrigerator cars 6,099.

Reports also showed 570 locomotives placed in service during the first three months this year, an increase of 140 compared with the first quarter in 1925, but a decrease of 91 locomotives compared with the first three months in 1924.

Class I railroads on April 1 had 738 locomotives on order, compared with 315 on the same date last year and 520 on the same date two years ago.

These figures as to freight cars and locomotives include new and leased equipment.

Motive Power Condition

Locomotives in need of repair on April 15 totaled 10,582 or 16.8 per cent of the number on line, according to reports filed by the carriers with the Car Service Division of the American Railway Association.

This was an increase of 391 locomotives compared with the number in need of repair on April 1, at which time there were 10,191 or 16.2 per cent. It was, however, a decrease of 1,484 locomotives compared with the number in need of repair on the same date last year, at which time there were 12,066 or 18.8 per cent.

Of the total number in need of repair, 5,693 or 9.0 per cent were in need of classified repairs on April 15, an increase of 328 compared with April 1, while 4,889 or 7.8 per cent were in need of running repairs, an increase of 63 within the same period.

Class I railroads on April 15 had 5,651 serviceable loco-

motives in storage, an increase of 281 locomotives compared with the number of such locomotives on April 1.

Freight Car Condition

Freight cars in need of repair on April 15 totaled 159,643 or 6.9 per cent of the number on line, according to reports filed by the carriers with the Car Service Division of the American Railway Association.

This was a decrease of 2,827 cars under the number reported on April 1 at which time there were 162,470 or 7.0 per cent. It was also a decrease of 30,522 cars compared with the same date last year.

Freight cars in need of heavy repair on April 15 totaled 116,981 or 5.1 per cent, a decrease of 1,238 compared with April 1. Freight cars in need of light repair totaled 42,662 or 1.8 per cent, a decrease of 1,589 compared with April 1.

Notes on Domestic Railroads

Locomotives

The Central Steel Company has ordered one six-wheel switcher from the American Locomotive Company.

The Delaware & Hudson Company is inquiring for from 5 to 15 Consolidation type locomotives.

The Union Railway of Pittsburgh has ordered 10 six-wheel switchers from the Lima Locomotive Works.

The Union Pacific Railroad is inquiring for 14 freight locomotives of the 4-12-2 type.

The Reading Company has ordered 5 locomotives from the Baldwin Locomotive Works.

The Charles R. McCormick Lumber Company has ordered one Mikado type locomotive from the Baldwin Locomotive Works.

The Fonda, Johnstown & Gloversville Railroad has ordered one six wheel switcher from the American Locomotive Company.

The Chicago, Rock Island & Pacific Railway has ordered 15 locomotives from the American Locomotive Company.

The American Railroad of Porto Rico has ordered one six wheel switching type locomotive from the Baldwin Locomotive Works.

The Bonhomie & Hattiesburg Southern Railroad has ordered one Prairie type locomotive from the Baldwin Locomotive Works.

The Utah Copper Company has ordered one 60-ton oil-electric locomotive from the Ingersoll Rand Company, General Electric Co. and American Locomotive Company.

The Yunnan Kopei Railway of China has ordered six switchers from the Baldwin Locomotive Works.

The Green Bay & Western Railway is inquiring for 2 three-cylinder Consolidation type locomotives, 2 Consolidation and 2 Mogul type locomotives.

The Sorocabana Railroad, of Brazil, has ordered 10 three-cylinder Mountain type locomotives from the Baldwin Locomotive Works.

The Pennsylvania Railroad plans to ask for bids shortly on 100 switch engines.

The Great Northern Railway has placed an order for one 100-ton oil-electric locomotive with the Ingersoll Rand Company, General Electric Co. and American Locomotive Company.

The Fruit Growers Express Company is inquiring for a four wheel saddle tank oil burning switching locomotive.

The Natchez, Columbia & Mobile Railroad has ordered through the Denkmann Lumber Company, one Mikado type locomotive from the American Locomotive Company.

F. C. del Amaga Company, Columbia, has ordered 2 Mikado type locomotives from the Baldwin Locomotive Works.

The Sorocabana Railway, Brazil, has ordered one Mikado type locomotive from the American Locomotive Company.

The Northern Pacific Railway is inquiring for 12 Mountain type locomotives.

The Union Pacific Railroad is inquiring for 14 freight locomotives of 4-12-2 type.

The Southern Pacific Company will build 5 Mountain type locomotives in its own shops at Sacramento, Calif.

The Essex Terminal Railway is inquiring for one six-wheel switcher.

The Delaware, Lackawanna & Western Railroad has ordered 25 heavy Mountain type three-cylinder locomotives from the American Locomotive Company.

The Chicago & Illinois Western Railroad has ordered 2 eight-wheel switchers from the Baldwin Locomotive Works.

The Illinois Central Railroad is inquiring for 20 Mountain type locomotives.

The E. B. Eddy Company, Ltd., Canada, has ordered one 0-4-0 type tank locomotive from the American Locomotive Company.

Passenger Cars

The International Railways, Central America, has ordered 16 first class and 17 second class passenger cars from the American Car & Foundry Company.

The Central Vermont Railway is inquiring for 14 steel underframes for milk cars.

The Pittsburgh, Shawmut & Northern Railway has ordered one combination passenger baggage gasoline rail motor car from the J. G. Brill Company, Philadelphia.

The Lehigh Valley Railroad is inquiring for 10 gasoline rail cars and 13 trailers.

The Southern Pacific Company is inquiring for 11 diners.

The Chicago & North Western Railway is having 3 self-propelled cars built by the Electro Motive Company.

The Erie Railroad is inquiring for 27 steel underframes for passenger cars.

The Delaware, Lackawanna & Western Railroad is inquiring for 2 sixty-foot combination mail and baggage cars.

The Philadelphia Municipal Subway is inquiring for 150 subway cars.

The Bangor & Aroostook Railroad is inquiring for one dining car.

The Great Northern Railway is inquiring for 10 steel underframes for baggage cars.

The Chicago, Burlington & Quincy Railroad is inquiring for 2 steel underframes for passenger cars.

The New York Central Railroad has ordered 10 multiple unit cars for suburban service from the Standard Steel Car Company.

The Southern Railway is inquiring for one steel underframe for a dining car.

The Reading Company is inquiring for 25 coaches and five passenger baggage cars.

The Seaboard Air Line Railway has ordered six passenger baggage cars from the American Car & Foundry Company.

The Missouri Pacific Railroad has placed an order for 5 gas-electric passenger baggage motor cars with the Electro Motive Company.

Freight Cars

The Texas & Pacific Railway has ordered 300 50-ton automobile cars from the American Car & Foundry Company.

The Atlantic Coast Line Railroad has ordered 1,000 low side gondolas of 50-tons capacity from the American Car & Foundry Company.

The Southern Railway has ordered 500 flat car underframes from the Tennessee Coal, Iron & Railroad Company.

The Chicago & North Western Railway will build 1,000 box and 500 stock cars in its own shops.

The Chicago, Rock Island & Pacific Railway is inquiring for 200 steel underframes.

The General Electric Company is inquiring for 6 flat cars.

The Chicago, Rock Island & Pacific Railway is inquiring for 450 40-ton box cars.

W. R. Grace & Company, New York, are asking for bids on 201 miscellaneous freight cars for South America.

The Missouri Pacific Railroad is inquiring for 4 air dump cars.

The Seaboard Air Line Railway has ordered 50 caboose cars from the American Car & Foundry Company.

The East Broad Top Railroad will build 25 hopper cars in its own shops.

The Central Vermont Railway is inquiring for 200 single sheathed 40-ton box cars, 200 40-ton underframes and 200 40-ton superstructures.

The Baltimore & Ohio Railroad has placed an order for parts, underframes and superstructures for 100 caboose cars and 16 dump cars, with the Pressed Steel Car Company.

The Monroe Sand & Gravel Company has ordered 4 air dump cars from the Koppel Industrial Car Company.

The Birmingham Southern Company has ordered 100 gondola cars from the Tennessee Coal, Iron & Railroad Company.

The Pere Marquette Railway has ordered 350 automobile box cars from the National Steel Car Company.

The International Railways of Central America are inquiring for 200 box cars.

The Texas & Pacific Railway is inquiring for 300 50-ton double sheathed automobile cars and 300 50-ton single sheathed automobile cars.

The International Railway, Central America, has ordered 25 flat cars of 20-ton capacity from the Magor Car Company.

The Consolidated Coal Company has ordered 900 mine cars from the Bethlehem Steel Company.

The Chicago, Burlington & Quincy Railroad is inquiring for 500 coal cars.

The Georgia & Florida Railway is inquiring for 450 40-ton box cars.

The Nevada Consolidated Copper Company has placed an order for 35 dump cars of 80-ton capacity with the Magor Car Company.

The Central Railroad of New Jersey has ordered 100 gondola cars from the Bethlehem Steel Company.

The Delaware, Lackawanna & Western Railroad is inquiring for 500 double sheathed 40 ft. box cars, 500 70-ton hoppers and 500 55-ton hoppers.

The Sinclair Refining Company has purchased 50 tank cars from the General American Car Company.

The Southern Railway is inquiring for 500 underframes for flat cars.

The Canadian National Railways has ordered 50 express refrigerator cars from the National Steel Car Corporation.

The Brazilian Railway is inquiring through the car builders for 40 air dump cars.

The South Porto Rico Sugar Company is inquiring for 16 flat cars of 40 tons' capacity. They are also inquiring for 100 sugar cane cars.

The Muncie & Western Railroad is inquiring for 50 single sheathed box cars of 40-tons capacity.

The National Tube Company is inquiring for 14 skelp cars of the 100-tons capacity. They are also inquiring for 25 car bodies.

The Ferrocarril de Pacifico, Colombia, is inquiring through the car builders for 50 flat cars of 30-tons capacity and also 100 box cars.

The Cuban American Sugar Company is inquiring for 100 sugar cane cars with steel underframes, of 15-tons capacity.

The Canadian National Railways has ordered 60 freight cars of 40-tons capacity from the Eastern Car Company, also 40 tank cars of 10,000 gal. capacity from the Canadian Car & Foundry Company.

Buildings and Structures

The Atlantic Coast Line Railroad has awarded a contract for the design and construction of a locomotive repair shop at Uceta, Fla., to cost approximately $1,000,000.

The Wabash Railway has placed a contract for an extension to its locomotive shops at Decatur, Ill., to cost approximately $800,000.

The Atchison, Topeka & Santa Fe Railway is planning to begin a $3,000,000 improvement project by building new yards and repair shops at San Diego, Calif.

The Central of Georgia Railway is asking for bids on an eighteen-stall addition to its enginehouse at Savannah, Ga.

The Gulf, Colorado & Santa Fe Railway has placed a contract for improvement to its shops at Cleburne, Texas, with Anderson Brothers, El Paso, Texas.

The Yazoo & Mississippi Valley Railroad is having plans prepared for extensive yard improvement and additional shops at Vicksburg, Miss.

The Norfolk & Western Railway has placed a contract for an extension to its shops at Portsmouth, Ohio, with the J. P. Pettijohn Company, Lynchburg, Va.

The Canadian National Railways has under construction the erection of an enginehouse and building for car facilities at Toronto, Canada, to cost approximately $300,000.

The Wabash Railway plans to build a repair shop at Detroit, Mich., to cost approximately $100,000.

The New York, New Haven & Hartford Railroad has awarded a contract for the erection of an enginehouse at Worcester, Mass., to cost approximately $150,000.

The Cleveland, Cincinnati, Chicago & St. Louis Railway are having plans prepared for the construction of an engine terminal at Riverside Yard, Cincinnati, Ohio, to cost approximately $3,000,000.

The Reading Company will build a new classification yard, with locomotive repair and shop facilities at Reynolds, near Mahoning City, Pa., to cost approximately $1,000,000 with equipment.

The New York, New Haven & Hartford Railroad is building an enginehouse at Cedar Hill, New Haven, Conn., to cost approximately $35,000.

The New York, Chicago & St. Louis Railroad has awarded a contract for the construction of a shop building at Frankfort, Ind., to cost approximately $50,000. The new structure will replace a building recently destroyed by fire.

The Pennsylvania Railroad has arranged a tentative program for extensions and improvement in the Pittsburgh district, including additions to the boiler and plate shops at the Pitcairn yards primarily for locomotive boiler works, to cost approximately $60,000.

The Chicago & North Western Railway will make addition and alterations to its Green Bay yards at Green Bay, Wis.

The New York, New Haven & Hartford Railroad plans to rebuild at once the machine shop which was destroyed by fire at East Hartford, Conn.

The Colorado & Southern Railway has under consideration the construction of an enginehouse and machine shop at Fort Collins, Colo., with complete locomotive repair facilities to cost approximately $100,000 with equipment.

The Pullman Car & Manufacturing Corporation is said to be considering the erection of a new car repair shop in the vicinity of Dallas or San Antonio, Texas, to cost $1,000,000 with equipment and machinery.

The Norfolk & Western Railway has awarded a contract for replacing its machine shop at East End Yard, Roanoke, Va., with J. P. Pettijohn & Company, Lynchburg, Va.

The Boston & Maine Railroad will soon start work on three coal plants at Lewiston, Rumford and Bangor, Maine, to cost approximately $250,000. The Lewiston project includes an enginehouse, storage buildings and turntable.

The New England Transportation Company, a subsidiary of the New York, New Haven & Hartford Railroad, plans to build a bus terminal at Fall River, Mass.

The Chicago, Rock Island & Pacific Railway has awarded a contract for the erection of a 400-ton frame coaling station at Washington, Iowa, also for a 400-ton frame coaling station at West Liberty, Iowa, and for a 300-ton frame coaling station at Enid, Okla.

The Texas & Pacific Railway plans engine terminals and repair shops at Gouldsboro, La., to cost approximately $1,500,000.

The Colorado & Southern Railway has under consideration the construction of an enginehouse and machine shop at Fort Collins, Colo., to cost approximately $100,000 with equipment.

The Atchison, Topeka & Santa Fe Railway are planning for the construction of a 43-stall roundhouse, several small shop buildings and extensive track facilities at Emporia, Kan., to cost approximately $500,000.

The Central of Georgia Railway has awarded a contract for the erection of a combination engine coaling and cinder handling plant at Eufaula, Ala., to the Roberts & Schaefer Company, Chicago, Ill.

The Chicago & North Western Railway plans the construction of a six stall extension to the roundhouse at Long Pine, Nebr.

The Chicago, Burlington & Quincy Railroad has awarded a contract for the construction of a 175-ton, two-track, reinforced concrete locomotive coaling station and electric cinder plant at Daytons Bluff, Minn.

The Chicago, Rock Island & Pacific Railway has under consideration the construction of a 20-stall roundhouse at Burr Oak, Ill.

The Illinois Central Railroad has awarded a contract for the construction of a heavy inspection shop building for electric locomotives at Burnside, Chicago, to cost approximately $300,000.

Items of Personal Interest

T. W. McCarthy has been appointed superintendent of motive power of the Chicago, Rock Island & Pacific Railway, to succeed **L. A. Richardson**, promoted.

Daniel J. Flynn has been appointed superintendent of the Mesabi division of the Great Northern Railway, with headquarters at Superior, Wis. **F. D. Kelsey** has been appointed superintendent of the St. Cloud division, to succeed **R. E. Landis**, who has been transferred.

L. F. Loree has been elected chairman of the board of directors of Missouri, Kansas, Texas Railroad and also been made chairman of the executive committee, to succeed **C. E. Schaff**, who retired as president.

W. J. Manley has been appointed assistant to the president of the Pittsburgh & West Virginia Railway, with headquarters at Cleveland.

W. T. Quirk has been appointed assistant to the general manager of the Atchison, Topeka & Santa Fe Railway, with headquarters at Los Angeles, Calif.

F. W. Webster has been elected vice-president and general manager of the San Jose Railroad, with headquarters at San Francisco, Calif., succeeding **F. E. Chapin**, deceased.

F. M. Clark has been appointed road foreman of engine of the Seaboard Air Line Railway, with headquarters at Arcadia, Fla.

Thomas J. Yonda has been appointed assistant boilershop foreman of the Union Pacific Railroad, with headquarters at Pocatello, Idaho, succeeding **John Vaughn**.

J. T. Lemly has been appointed foreman of the steel car repairs of the Southern Railway, with headquarters at Spencer, N. C., succeeding **G. V. Eagle**, promoted.

Richard Kling has been appointed general roundhouse foreman of the Missouri Pacific Railroad, with headquarters at Kansas City, Mo.

W. H. Fetner, chief mechanical officer of the Missouri Pacific Railroad, has had his authority extended to include the Gulf Coast Lines and the International Great Northern, with headquarters at St. Louis, Mo.

Irving Blodgett has been made assistant to the mechanical superintendent of the Boston & Maine Railroad, with headquarters at Boston, Mass.

J. W. Redus has been made erecting shop foreman of the Gulf Coast Lines, with headquarters at Kingsville, Texas, succeeding **L. F. Breaker**, transferred to Vanderbilt as mechanical foreman.

J. J. Horrigan has been appointed night roundhouse foreman of the Union Pacific Railroad, with headquarters at Grand Island, Nebr., succeeding **H. H. Turner**, transferred to Kearney, Nebr.

T. J. Leach has been appointed master mechanic of the Pennsylvania Railroad, with headquarters at Altoona, Pa., succeeding **G. J. Richers.**

H. Israel has been appointed division engineer, Illinois division of the Missouri Pacific Railroad, with headquarters at Illmo, Mo. **R. G. Bush** has been appointed division engineer of the Kansas City Terminal division, with headquarters at Kansas City, Mo. **W. F. Murray** has been appointed assistant division engineer of the Colorado division, with headquarters at Hoisington, Kansas, to succeed Mr. Bush.

L. O. Murdock has been appointed superintendent of the Alliance division of the Chicago, Burlington & Quincy Railroad, with headquarters at Alliance, Nebr., to succeed **L. C. McBride**, who has been appointed superintendent of the McCook division, with headquarters at McCook, Nebr., to succeed **M. F. MacLaren,** who has resigned.

Samuel Miller, formerly general superintendent of transportation of the Boston & Maine Railroad, has been appointed general superintendent of the entire system, to succeed **John Rourke**, deceased.

E. R. Tattershall has been appointed division engineer of the St. Lawrence division of the New York Central Railroad, with headquarters at Watertown, New York. **A. R. Jones,** has been appointed division engineer of the Pennsylvania division, with headquarters at Jersey Shore, Pa., and **S. E. Armstrong** has been appointed division engineer of the River division, with headquarters at Weehawken, New Jersey.

J. W. Mode has been appointed acting superintendent of the Amarillo division of the Fort Worth & Denver City Rail, way, with headquarters at Childress, Texas, to succeed **R. G. Fitzpatrick,** who has been granted a leave of absence because of ill health.

W. C. Higginbottom, superintendent of the Pan Handle division of the Pennsylvania Railroad, with headquarters at Pittsburgh, Pa., has been appointed superintendent of the Philadelphia division, to succeed **W. L. Elkin. E. Y. Geddes,** superintendent of the Toledo division has been appointed superintendent of the Pan Handle division, to succeed W. C. Higginbottom.

C. L. Beale has been appointed assistant general manager of the Florida East Coast Railway, with jurisdiction over the transportation and maintenance of way department.

Leroy Relyea has been appointed assistant superintendent of the River division of the New York Central Railroad, with headquarters at Weehawken, New Jersey.

G. W. Cuyler, master mechanic on the Chicago, Rock Island & Pacific Railway, with headquarters at Horton, Kan., has been transferred to Des Moines, Iowa, succeeding **T. W. McCarthy,** who has been promoted to superintendent of motive power.

Norman M. Lack has been appointed assistant to the general manager of the Alaska Railroad, with headquarters at Anchorage, Alaska.

Franklin D. Davis has been appointed general superintendent of transportation of the Western region of the Pennsylvania Railroad, with headquarters at Chicago, Ill.

E. L. Bachman, assistant master mechanic of the Pan Handle division of the Pennsylvania Railroad, with headquarters at Cully, Pa., has been appointed master mechanic of the Wheeling division, with headquarters at Mingo Junction, Ohio.

Supply Trade Notes

H. M. Curry, Jr., was elected president of the **Premier Staybolt Company,** of Pittsburgh, at a recent meeting of the board of directors; **J. F. McGann** was made assistant sales manager and **C. B. Woodworth** was appointed technical representative.

The **American Car & Foundry Company** was moved its New York office from 165 Broadway to 30 Church street.

Fred A. Poor, formerly president of the **P. & M. Company,** was elected chairman of the board of directors, and **Philip W. Moore,** formerly vice-president, was elected president.

K. E. Kellenberger, eastern manager of the **National Safety Appliance Company,** with headquarters at Chicago, has resigned to handle publicity work for the **Union Switch & Signal Company,** with headquarters at Swissdale, Pa.

George T. Ramsey has been appointed railroad department representative of the eastern territory of the **United Alloy Steel Corporation,** Canton, Ohio, with headquarters at Pershing Square building, New York City.

T. D. Graham, who formerly represented the **Republic Iron & Steel Company** at New York, has assumed charge of the Cleveland territory of the **Reading Iron Company,** with headquarters at 850 Euclid avenue, Cleveland, Ohio.

R. R. Baxter, superintendent of the car building plant of the **Tennessee Coal Iron & Railroad Company,** has been appointed assistant to the vice-president, with headquarters at Birmingham, Ala. **N. L. Van Tol** has been appointed general superintendent, to succeed Mr. Baxter.

W. C. MacFarlane, vice-president and general manager of the **Minneapolis Steel & Machinery Company,** Minneapolis, Minn., has been elected president.

The **Rail Joint Company** has moved its New York office from 61 Broadway to 165 Broadway, New York City.

Edwin S. Mills, general manager of sales of the **Illinois Steel Company,** Chicago, has been elected a vice-president.

Newton E. Dabolt, who has been general sales manager in charge of sales for both the lacquer and leather cloth divisions of the **Zapon Company,** has resigned.

Avery Adams has been appointed assistant general manager of the sales of the **Trumbull Steel Company,** Warren, Ohio, to succeed **Arthur Long,** resigned.

J. Reis, vice-president of the **United State Steel Corporation,** with headquarters at New York, has resigned and will retire from active business.

O. M. Hullinger, sales engineer for the railroad department of the **Ohio Brass Company,** Mansfield, Ohio, has been transferred from New York office to Chicago office, with headquarters in the Fisher building.

Albert Roberts has been appointed district manager of the southern territory of the **Duff Manufacturing Company,** Pittsburgh, Pa., with office in the Candler building, Atlanta, Ga., and **George E. Watts** has been appointed special representative in the Southern district, with headquarters at Candler building, Atlanta, Ga.

J. V. O'Neil has been appointed district representative of the **General American Tank Car Corporation,** with headquarters in the Gosden building at Tulsa, Okla., succeeding **R. J. Sharpe,** who has been transferred to the general office at Chicago, Ill., as general sales manager.

The **Gould Car Lighting Corporation,** a subsidiary of the **Could Coupler Company,** of Depew, New York, has been organized recently in Maryland to take over the car lighting business of the parent company. The officers of the new company are: **W. S. Gould,** president; **J. A. Sauer** and **Donald S. Barrows,** vice-presidents; **P. P. Meade,** treasurer, and **Bickett Nairn,** secretary and assistant treasurer. **W. F. Bouche,** formerly superintendent of the car lighting department of the **Gould Coupler Company** at Depew, will be manager of the new corporation, with headquarters at Rochester, New York.

Taylor Allderdice has been elected president of the **National Tube Corporation,** the pipe subsidiary of the **United States Steel Corporation.**

Howard B. Jernee has been appointed sales manager of the line shaft bearing department of the **Hyatt Roller Bearing Company,** Newark, N. J., succeeding **Frank S. Cole.**

The **Madison Kipp Corporation,** of Madison, Wis., has moved its Chicago office from 306 South Wabash avenue to 2750 North Lincoln street. **William B. Wheeler** is general manager in charge of the railroad department.

The **Southern Iron & Equipment Company,** Atlanta, Ga., announces the following changes, **H. M. Pratt,** formerly general sales manager, has been elected second vice-president, and **R. A. Garner** has been made secretary and treasurer, to succeed **A. J. Merrill,** deceased.

The **Bucyrus Company** has moved its Pittsburgh district office from the Union Trust to the Commonwealth building. As formerly, the office is in charge of **A. R. Hance,** district sales manager.

J. McA. Duncan, who has been district manager for the **Westinghouse Electric & Manufacturing Co.** at Pittsburgh for the past fourteen years, has been promoted to assistant general sales manager, effective May 1. **W. R. Marshall,** formerly branch manager at Buffalo, has been chosen to fill the place vacated by Mr. Duncan. **H. F. Boe,** formerly industrial division manager at Buffalo, has been promoted to branch manager of that office, and **R. L. Kimber** has been made industrial division manager. **W. F. Barnes** has been appointed branch manager of the Tulsa office.

Obituary

Andrew Charles Loudon, vice-president of the Superheater Company, Ltd., Montreal, died at his residence, in Burlington,

Vermont, on Sunday evening, April 11, 1926. Death resulted, after a few days illness, from influenza and pneumonia, and came as a great shock to his family and relatives, as well as to the wide circle of friends and business associates.

Mr. Loudon was born July 7, 1883, at Valleyfield, Quebec. After receiving public school and high school education, he entered upon an apprenticeship course with the Canadian Pacific Railway in 1901, and, upon completion, entered McGill University in 1902, from which he was graduated in 1906 with a degree of Bachelor of Science. He then entered the employ of the American Locomotive Company and was employed in the engineering department until 1907, when he went with the Grand Trunk Railway as roundhouse foreman at Island Pond, Vermont. In 1909 he became draftsman for the Delaware & Hudson Railroad at Green Island, New York, and later joined the test department of the Atchison, Topeka & Santa Fe Railway. In 1910 he was employed in railway construction work by the Grand Trunk Pacific Railway and later was foreman of locomotive and car repair. Leaving railway work in 1912, he became associated with the Simmons-Boardman Publishing Company as assistant editor in charge of the Car Builders' Dictionary, subsequently becoming associated editor of the Railway Mechanical Engineer. Mr. Loudon became assiciated with the Superheater Company of New York in April, 1917, and served with distinct ability in the engineering and service departments of this company until July, 1920, when he was placed in charge of the Superheater Company, Ltd., of Canada, of which he became vice-president in January, 1921, and in which capacity he was serving at the time of his death.

Mr. Loudon was a member of the Engineering Institute of Canada, the American Society of Mechanical Engineers, the Engineers' Club of Montreal, the Waubanakee Golf Club of Burlington, University Club of Montreal, the Trout Club of Vermont, the Ethan Allen Club of Burlington, St. Georges Club of Sherbrooke, St. Francis Golf Club of Sherbrooke, Green Mountain Club of Rutland, the First Congregational Church of Burlington and a member of other social and fraternal organizations.

He was a man of remarkably keen sympathy and was ever mindful of the opportunity to be of help and assistance to those in trouble. The large number of messages of condolence from men in all parts of the United States and Canada, expressing their high regard for Mr. Loudon and their sense of keen personal loss, is an eloquent tribute to his high character and ideals and to the high standing which he had attained in his chosen line of activity.

Willard G. Carlton, superintendent of power, electric divison and Grand Central Terminal, New York Central, died on Thursday, April 15, after a very brief illness. Mr. Carlton was born on February 20, 1869, in Warren, Ill., and was educated at the College of Mechanical Engineering, Cornell University, and was graduated from there in 1892. He was in charge of the operation of power station, substations, transmission and distribution system, terminal service and boiler plants, and the supply of heat, light and power to the buildings in the Grand Central Terminal.

F. O. Bailey, manager of sales of the Gold Car Heating & Lighting Company, New York, died at his home in Brooklyn, N. Y., on April 14, 1926.

New Publications

Books, Bulletins, Catalogues, etc.

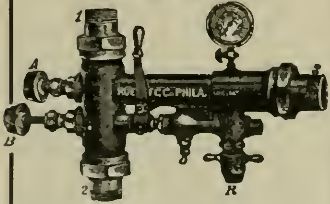
Locomotive Data. The Westinghouse Electric & Manufacturing Company has released six additional sheets of Locomotive Data, Leaflet 20190, sheets 21 to 26, inclusive, covering Virginia, Detroit, Toledo & Ironton; Buenos Aires and Western; Imperial Government Railways of Japan; Norte Railways of Spain, and Dutch East Indies State Railway.

Each sheet covers a certain type of locomotive giving the salient mechanical and electrical data of that particular type. These sheets can be furnished separately or in complete sets by addressing the Publicity Department, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

Uninterrupted Signal Power. This is an illustrated booklet issued by the Electric Storage Battery Co., Philadelphia. The booklet describes the manner in which the a.c. floating battery system functions. This method of supplying a constant current was developed about six years ago by the joint invention of Robert M. Phinney, assistant signal engineer, Chicago Northwestern Railway, and H. M. Beck, operating engineer of the Electric Storage Battery Co. This booklet, describing the a.c. floating battery system in more detail, may be secured by addressing the company at its Philadelphia office.

Power Factor and Means for Its Improvements. This is an illustrated pamphlet issued recently under the serial number GEA-232, by the General Electric Company, Schenectady, N. Y. It presents in a simple and systematic manner authoritative information on means for power improvement in industrial and other plants. It is a practical treatise on power factors with the mathematics reduced to simple arithmetic.

Some Developments in Electrical Industry During 1925, by John Liston. This review put out as publication GEA-355, by the General Electric Company, Schenectady, N. Y., covers every phase of electrical application and its outstanding development during the past year. It is divided into numerous sections; contains illustrations and an index.



Railway and Locomotive Engineering

A Practical Journal of Motive Power. Rolling Stock and Appliances

Vol. XXXIX 136 Liberty Street, New York, June, 1926 No. 6

Three-Cylinder Locomotive Performance Record

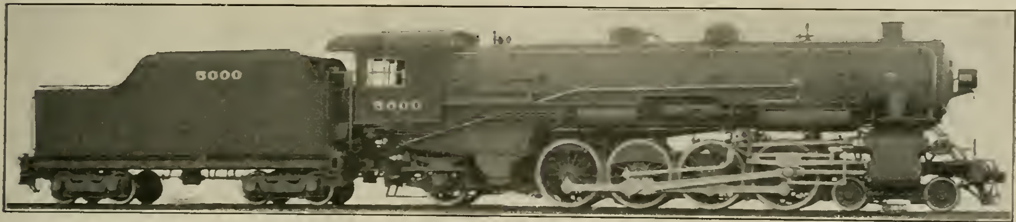
Shows Low Maintenance Cost Per Locomotive Mile for the Design

Among the many interesting exhibits at the Atlantic City Conventions is locomotive No. 5000 of the Lehigh Valley Railroad which went into service in March, 1924, and which was exhibited at the June conventions that year. It was the forerunner of a large number of three-cylinder engines which have since been constructed by the American Locomotive Company and details of its performance and maintenance is of interest.

The locomotive was described in the February 1924 issue of Railway and Locomotive Engineering, and tests of its performance on the Lehigh Valley Railroad appeared in the April, 1924, issue.

The locomotive is of the 4-8-2 type and in working order weighs 369,000 lb., the weight on the driving wheels being 246,500 lb. Driving wheel base 41 ft. 2 in. The cylinders are 25x28 in.; boiler pressure 200 lb.; maximum tractive effort 64,700 lb.; and factor of adhesion 3.81. Driving wheel diameter is 69 in.

It was placed in service on the Buffalo Division between Tiffts Farm and Lancaster, about 94 miles. The ruling grade is 0.4 per cent and approximately 28 miles long. The heaviest locomotive on the Lehigh Valley is rated at 3,750 tons on the division, this being a Santa Fe type with maximum tractive power of 72,000 lb. Locomotive 5,000 has actually handled 4,540 tons over this division, in 70 cars, in 4 hr. 45 min., and on another occasion handled 4,619 tons in 94 cars, in 5 hr. 6 min. at an average speed of 18.57 m.p.h. It was also tried on the Wyoming Division, 150 miles long, with maximum grades 1.17 per cent for about 20 miles eastbound, and 1.23 per cent for about 10 miles westbound. The locomotive was tried on this division to ascertain the possibilities of using it on a milk train the schedule of which is fast and which had been handled by two Pacific type locomotives. In order to try the three cylinder locomotive on this run, a 36-car train weight 1,350 tons, approximately 150 tons more than the ordinary milk train, was made up, and left Sayre 1 hr. 15 min. late. The locomotive took the train over the mountain, and arrived at Lehighton, 150 miles, 12 min. late. Also, approximately 1,560 tons, in 38 milk cars and 2 cabooses, were taken out of Lehighton 7 min. late, and arrived at Sayre 5 min. late in spite of 15 min. delay on the road. During this trip an average of 55 m.p.h. was maintained for 38 miles. One of the outstanding features of the locomotive has been the ability of the boiler to maintain average boiler pressure under all conditions of service. Based on the Cole method of calculating locomotive boiler ratio for 2-cylinder locomotives, the boiler h.p. figures out at only 86 per cent of cylinder h.p. This figure, however, does not indicate the true percentage, because of the difference in draft, due to 6 exhaust impulses, instead of 4 as in the 2-cylinder locomotive. Official figures obtained from actual test of locomotive 5,000 show evaporation of approximately 7.5 lb. of water per lb. of coal. Coal consumption on test runs showed under 60 lb. per 1,000 gross ton miles. On one test run the coal per indicated h.p. was a little less than 2.6 lb., with an average cut-off of 53 per cent, no deduction being made for coal used in supplying steam to auxiliaries.



Three Cylinder Mountain Type Locomotive in Service on the Lehigh Valley Railroad—Built by the American Locomotive Company

Since June of 1924 engine No. 5,000 has been regularly assigned to milk train No. 38 eastbound, and No. 21 westbound, making alternate trips each day with another similar three-cylinder locomotive.

Milk train No. 38, eastbound, is composed of from 19 to 25 loaded milk cars, depending upon the season. Train No. 21, westbound, is composed of from 38 to 43 empty milk cars, also depending upon the season.

Eastbound from Wilkes-Barre to Mountain Top is a long grade, five miles of which is 54.9 ft. to the mile, and 14 miles 61.5 ft. to the mile. Westbound from Lehighton

to Mountain Top are 24 miles averaging 35.0 ft. to the mile and 11 miles 64.0 ft. to the mile.

Train No. 38 is operated on a very severe schedule, requiring a sustained speed of from 50 to 55 miles per hour over the entire division with the exception of the heavy grade over the mountain. Formerly this train was handled by a heavy Pacific type locomotive which was double headed over the mountain. The three-cylinder locomotive handles this train without helper except in cases of a severe snowstorm.

Up until May 26, 1926, when engine No. 5000 was taken out of service in order to be shipped to Atlantic City, this locomotive had a mileage of 99,018.

On February 5, 1925, engine No. 5000 was taken in the shop and given Class 5 repairs. It was released on February 21st. Again on November 10, 1925, it was taken in the shop and given Class 5 repairs. It was again released on December 5th. Since last Class 5 repairs it has made 23,300 miles.

A large number of three-cylinder locomotives were built by the American Locomotive Company during 1924 and 1925. The tractive effort of these locomotives ranged from 29,800 lb. in the case of one built for the Japanese Government Railways, to 96,650 lb. of the Union Pacific 4-12-2 type. Details of the latter engine appeared in RAILWAY AND LOCOMOTIVE ENGINEERING for May, 1926.

The Distribution for Locomotive Weights

A Survey of the Changes in Distribution of Weights on Wheels After Locomotives Have Been in Service

Cases have been reported where the calculated distribution of weights on the wheels of a locomotive as made in the drawing room have been approached so closely by the shop construction as to seem almost uncanny. In one instance there was a variation of less than 500 lbs. in the weights on the two sets of driving wheels of a Mallet locomotive, whose total weight was between 400,000 and 500,000 lbs.

Usually the theoretical weights on driving wheels, where the equalizing lever, a properly designed, should be about the same. But track conditions and the position of the locomotive upon the same, cause constant and varying differences to occur.

However well a locomotive may have been designed wear and tear and back shop repairs will cause changes to take place in the weight distribution on the wheels, some of which may be of a permanent character and may even affect the operation of the locomotive.

Noticing indications that seemed to point to the occurrence of such changes in some Atlantic locomotives, under his charge, a superintendent of motive power of a well-known road had a survey made of fifty-eight of these locomotives, in order to determine what, if any changes had taken place in the distribution of weights on the wheels. In order to be able to appreciate the situation at a glance the results were put in the form of diagrams which are herewith reproduced.

The engines were classified in two series which are here designated as the X-1 and X-2 classes.

The X-1 class had cylinders 20½ in. in diameter and a piston stroke of 26 in., and weighed when new about 187,000 lbs. of which about 32,000 lbs. was on the front truck; 60,000 lbs. on the first pair of drivers; 63,000 lbs. on the second pair of drivers and 32,000 lbs. on the rear truck. The X-2 engines were identical with the X-1 so far as size of and total and distribution of weights are concerned. In this it will be noticed that the weight on the rear or main drivers was 3,000 lbs. more than it was upon the front driving wheels.

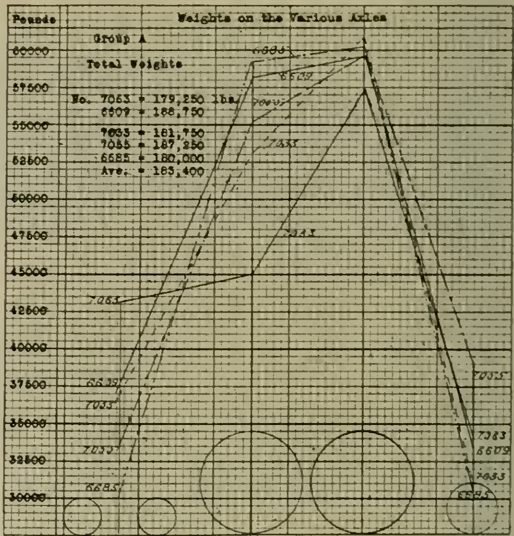
The survey, here set forth was made after the engines had been in service and been subjected to one or more general overhauling, during which, in some instances, changes had been made in the specialties with which they were equipped which altered the weights and was probably the cause of some of the variations in the distribution.

The X-1 class was divided for convenience in diagramming into two groups the *A* and *B*.

In all of these diagrams the figures attached to the several lines indicate the numbers of the engines surveyed and are used for purposes of identification.

In what follows it has been assumed that the original distribution of weights checked exactly with the schedule. Of course this is not strictly the case so that some latitude must be allowed. But, in a general way, it is believed that the analysis is correct.

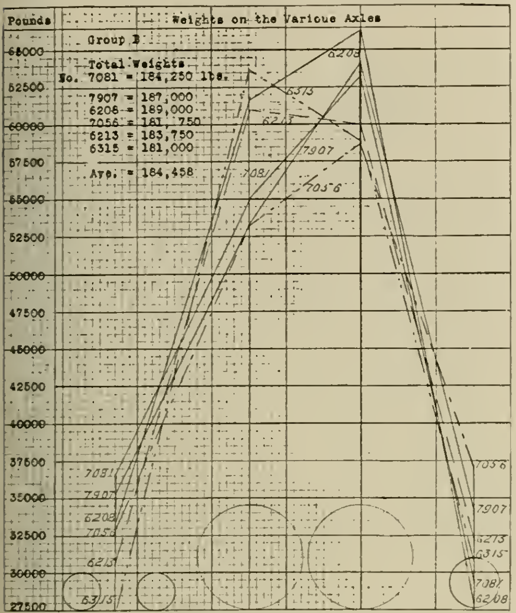
In the *A* group we notice a tendency of three out of the



five locomotives to increase the weights on the front truck and to lose weight on the front drivers relatively to the rear pair. In one case, that of No. 7063, the increase on the front truck was very pronounced, amounting to 11,000 lbs., most of which was probably at the expense of the front drivers, though there was a total loss of weight on the whole engine of nearly 8,000 lbs. It is probable that this involved other changes than mere wear and tear. At any rate the increase of weight on the front truck caused a redistribution of weight that was well removed from the desirable.

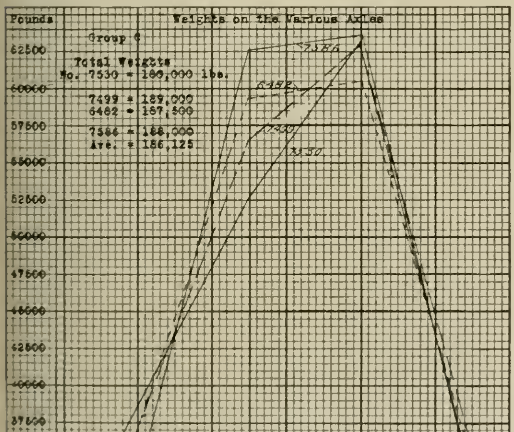
In group *B* four out of the six locomotives show un-

desirable variations from the original weights on the driving wheels. One main pair of drivers show an increase of 3,000 lbs. and three fall from 3,000 lbs. to 4,000



lbs. below the prescribed weight. In not a single instance is the difference of 3,000 lbs. between the two pair maintained.

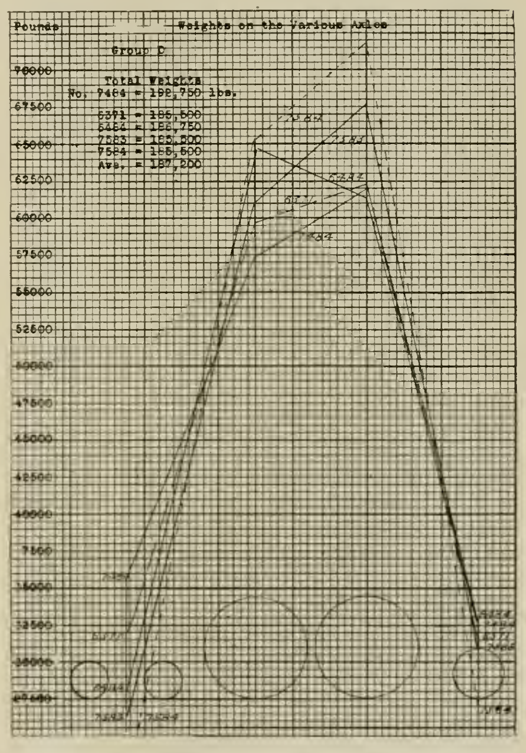
In two cases the weight on the front drivers has



become greater than that on the rear. There is also a variation from 4,500 lbs. less to 4,000 lbs. more on the front trucks than the schedule calls for. In two cases the weights on the rear drivers are very close to the schedule and in one case on the front drivers; but, in each of these the other pair of wheels show wide variations from the schedule.

The X-2 class is shown divided into ten groups, designated as from *C* to *L* inclusive. In group *C* there are three locomotives, the weights on whose main drivers are very close to the schedule, and as to one of which the same may be said regarding the front driver. In one case there is an increase of 4,500 lbs. on the front trucks and a loss of about 7,500 lbs. on the front drivers. In not a single instance is the difference of 3,000 lbs. between the front and rear drivers held.

In group *D* there is an appearance of some interchange of distribution. On engine 7484 the weight on the front truck increased 3,500 lbs. above the schedule, while the



front drivers lost 2,500 lbs.; and the front truck on No. 6484 lost 4,000 lbs., while the front drivers gained 4,500 lbs. Again in only one instance was the difference of 3,000 lbs. between the two pair of driving wheels maintained.

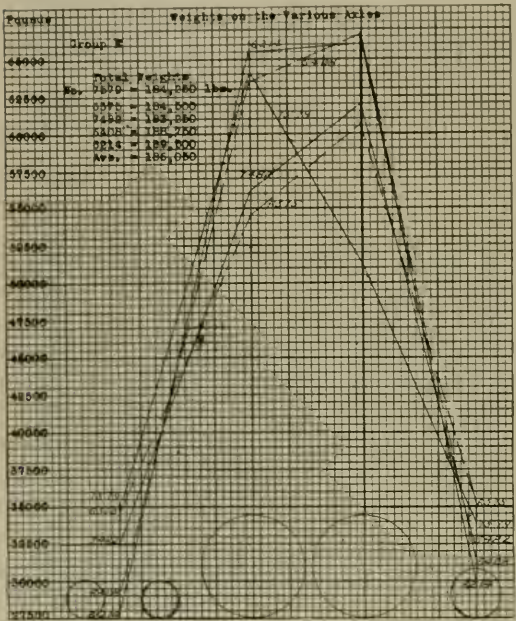
In group *E* we have a case of a remarkable falling off of weight on the rear drivers of engine No. 7579. And in not a single instance are the weights on the front drivers near the schedule and in only one case do those of the rear drivers come within 1,000 lbs. of the same.

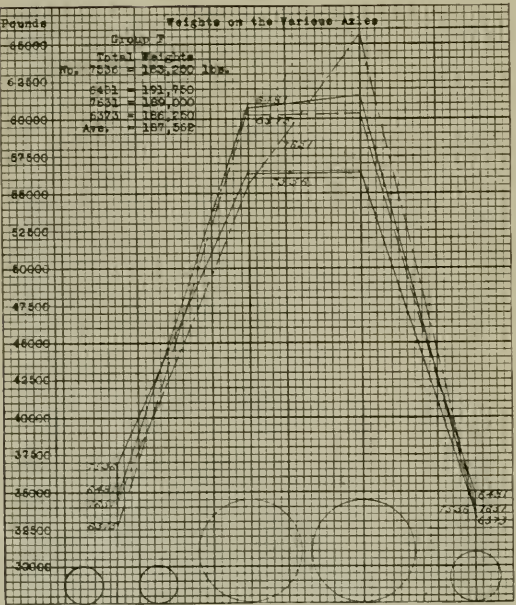
In two cases the weight on the front drivers rose while those on the rear fell, leaving the total in one case only 750 lbs. below the total of the schedule. In another case (No. 7631) the front pair lost weight while the rear gained so as to leave the total of the two 121,000 lbs., instead of 123,000 lbs.

In group *G* there is a loss on all drivers, in two instances

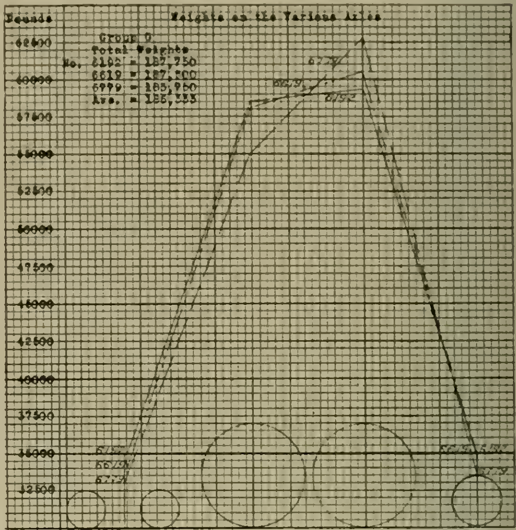
with a gain on the front truck, leaving totals for the three somewhat below the schedule.

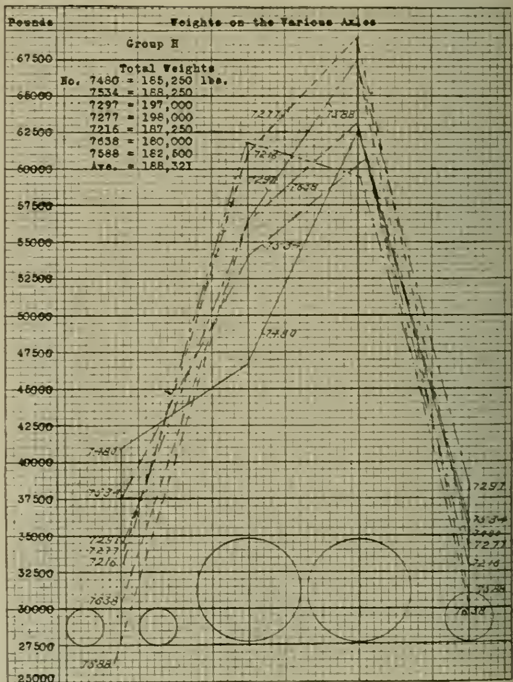
In group *H* we have cases of considerable variation. In only two cases are the weights on the rear drives near





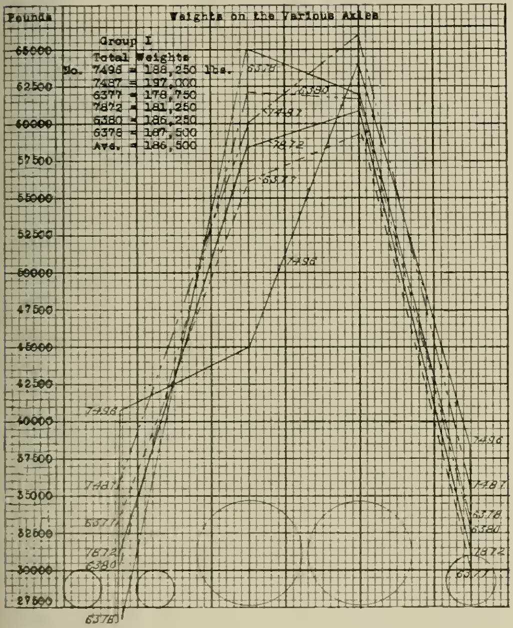
the schedule and, on one of these (No. 7480) the front pair of drivers have lost 13,500 lbs. while the front truck has gained 9,000 lbs. and the rear truck 3,500 lbs., leaving a net loss after all the variations of but 1,000 lbs. In case, No. 7216, the front drivers gained about 1,750 lbs. and the rear lost 3,500 lbs. The loss was probably a genuine engine loss, as the rear truck also shows a loss.





In group *I* we have another instance of a great increase of weight on the front truck with a corresponding loss on the front drivers, with but little variation on the rear

drivers. Similar instances are to be found in groups *A* and *H*. In this case the front truck increased 8,750 lbs.; the front driver lost 15,000 lbs.; the rear driver gained 1,000 lbs. and the rear truck gained 6,500 lbs. This indicates the engine as weighing 1,250 lbs. more than the schedule, with the probability that the variations are due to either bad original adjustments or a shifting of the same in service. In one case there is an unexplained increase of 10,000 lbs. in the total weight above the



schedule. But the variations in truck and driver weights from the schedule are greater than should be desired.

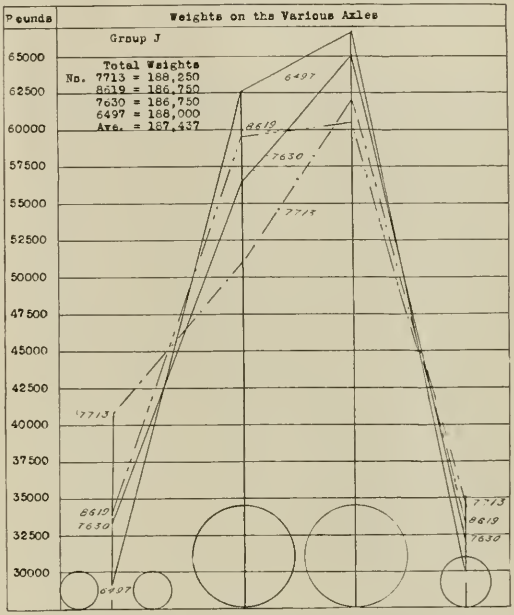
In group *J* we have a case of a loss of about 5,000 lbs. on the two trucks and an increase of 6,000 lbs. on the drivers. Also another case of great increase of weight on the front truck, with a corresponding loss on the front drivers.

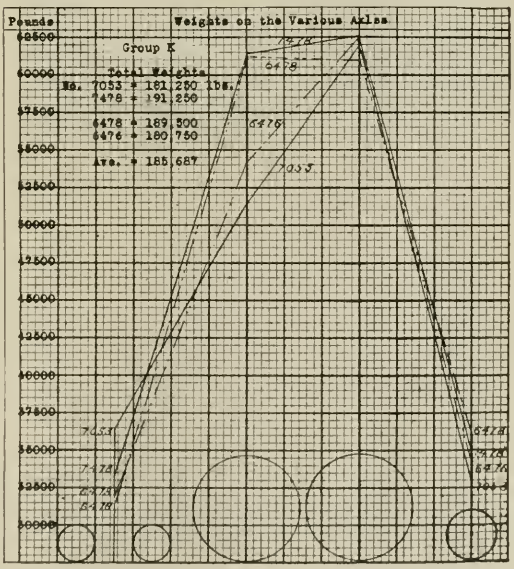
This is repeated to a certain extent in the case of engine No. 7053 of group *K;* and again on engine No. 7381 of group *L* though in this case, with the exception of the front truck, there is a notable loss of weight at each point of support.

Here we have a total of 58 locomotives. On the basis that the distribution of all weights was originally in accordance with the schedule, we find that, in 38, the weight on the front truck increased; in 18 it decreased and in 2 it remained normal. In one of these latter cases there was a total loss of weight of the engine, which would mean a relative increase in the weight on the front truck. In the other case there was an increase in the weight of the engine, meaning a relative loss of weight on the front truck; so that we may take it that the weight on the front truck increased on 39 locomotives and decreased on 19.

As to the front drivers there was an increase of weight on 19 engines; one held to the schedule where the total weight increased, making this a relative loss; while 38 engines lost weight, leaving the result as a gain in 19 instances and a loss in 39.

Of the rear drivers, 21 gained in weight; 33 lost and 4 remained normal. By an adjustment of the four normal weights to correspond to a total increase or decrease in the weight of the engines, we find that, of these, three show





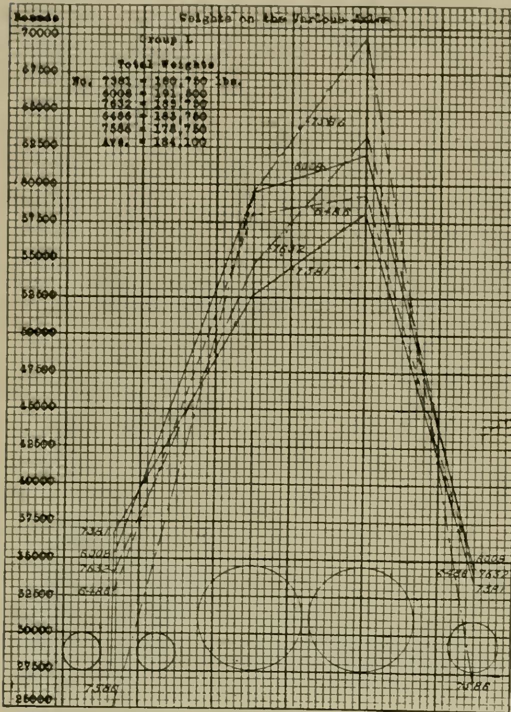
a relative loss, so that we have 24 showing a gain and 34 a loss.

In the case of the rear truck 39 engines showed an increase of weight; 3 were normal and 16 showed a loss of weight.

Where the points of support show a loss of weight, it may be accounted for, in part at least, by wear and tear,

but an increase above the schedule can only be accounted for by a change of adjustment or overweight in the new machine.

Fifty-eight is but a small percentage of all of the Atlantic (4-4-2) locomotives in the country, and it would be unsafe to draw final conclusions from a survey of so small a number. But from the data at hand it would appear that there is a tendency of the weight on the front truck to increase at the expense of that on the front driver. Also that the same thing occurs with the rear truck relatively to the rear drivers.



This loss of driver weights may be serious. Their total scheduled weights were 123,000 lbs., yet we find, in a number of cases, a loss of 14,000 lbs. and, in one case 21,000 lbs. in weight on drivers. As these are 11.38 per cent and 17.07 per cent of the scheduled weights, such a loss may well result in excessive slipping.

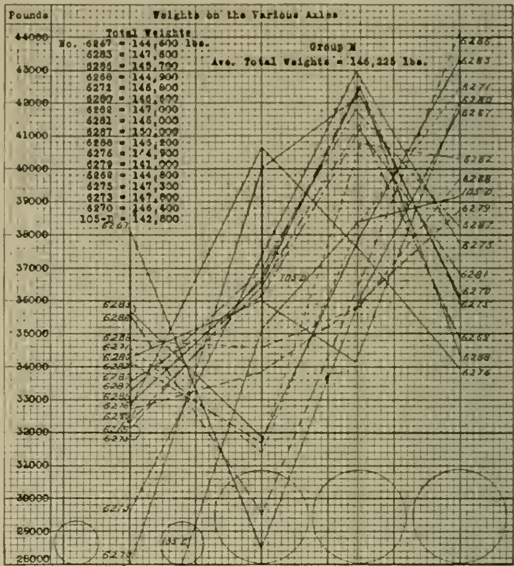
It is impossible to analyze the causes of these changes from the information obtained from the diagrams alone; but the results are such as to be well worth watching.

A similar survey was also made of seventeen ten-wheelers (4-6-0 type). These engines had cylinders 19 in. in diameter with a piston stroke of 24 in., and weighed 146,500 lbs. Of this weight 30,500 lbs. was upon the front truck; 37,000 lbs. on the front pair of drivers; 41,000 on the second, and 38,000 on the rear pair of drivers.

The diagrams show the variations due to a redistribution of the weights, and yet, as shown by the table of total weights the actual variations from the schedule was not excessive.

Take engine No. 6267 as a flagrant example. The total loss of weight was only 1,900 lbs.; yet there was an increase of 7,700 lbs. on the front truck; a loss of 8,400 lbs. on the front drivers; a loss of 5,000 lbs. on the second pair of drivers and an increase of 3,800 lbs. on the rear pair of drivers. The total weight on drivers should have been 116,000 lbs. but it was reduced to 106,400 lbs., or to 91.72 per cent of the standard.

This was the worst case presented; but, of the seventeen locomotives surveyed, fifteen showed an increase of weight



on the front truck and thirteen showed a loss of weight on the front drivers. Five showed an increase on the second pair of drivers and ten on the rear pair.

With such conditions as these existing it is small wonder that the crews report unsatisfactory action without being able to make any definite statement as to just what may be the matter.

Without being able to suggest a definite remedy, it may be well to watch engines going through the shop to see that no changes in adjustments are made, and also to watch the operation on the road in order to ascertain if the mere act of working and running has a tendency to transfer more weight to the front truck than it is normally expected to carry. At any rate such surveys as these are interesting and valuable as showing what may occur in the readjustment of the weights on the wheels of a locomotive.

Oil-Electric Locomotive in Logging Service

The Red River Lumber Company will place a 100-ton oil electric locomotive in service about July 15 and the Utah Copper Company will place a 60-ton unit in service at Bingham, Utah.

The 100-ton locomotive of the Red River Lumber Co. will be employed in hauling logs out of the woods and hauling supplies in over a line 15 to 20 miles in length. Maximum grades of two to three per cent will be encountered. It will probably be necessary to cut the trains and take them in sections over these grades, the numbers of cars in each section depending on the amount and length of the grade. The 60-ton locomotive purchased by the Utah Copper Co. will be employed in hauling waste cars on the upper levels at its mine at Bingham, Utah.

Railway Fuel Association Convention

Interesting Addresses and Reports Made at Highly Successful Annual Fuel Convention

The eighteenth annual convention of the International Railway Fuel Association was held at the Hotel Sherman, Chicago, May 11 to 14. This was the largest and most successful meeting ever held by this association. The attendance was well over 2,000, and included members, guests and representatives of railway supply manufacturers.

The first day's session was devoted to subjects and reports of interest to those of the operating department; the second day to the accounting, engineering and purchasing departments, and the third day's session to such subjects and reports of value to those engaged in the mechanical department.

Abstracts of the principal addresses made on three of the days by A. E. Clift, vice-president of the Illinois Central Railroad; H. R. Stafford, vice-president of the Missouri Pacific Railway and C. E. Brooks, chief of motive power, Canadian National Railways, are presented as follows:

Railroads Are Still Progressing

By A. E. Clift, Senior Vice-President Illinois Central Railroad

Remarkable things have taken place in the world since the advent of the steam locomotive. The continents of Europe and North America, in particular, have witnessed a development far greater during this last century than took place in all the centuries that went before. The progress of the world in the last one hundred years has been an indirect result—not of the railroad, for roadways of rail were in use more than three centuries ago—but of the steam locomotives. As the automobile has transformed our main highways from ruts and sloughs and mud-holes into the smooth-surfaced pavements of today so the steam locomotive has been the important factor in the development of our modern railroads. Probably no other one invention has had such a profound influence upon mankind and such a stimulating effect upon human progress.

There is approximately one mile of railroad for every 75 square miles of land area on the globe or for every 2,400 members of the human race. Our own nation, youthful as it is in comparison with the countries of the Eastern Hemisphere, embraces 250,000 miles of first track and 415,000 miles of all track. With only one-sixteenth of the world's population and only one-eighteenth of the world's land area, we have in this country more than one-third of the total railway mileage of the world. We have one mile of railroad for every 440 of our population and for every 12 square miles of land area.

The railroads are a gigantic industry in themselves. They purchase from the other industries of the country fuel, materials and supplies costing around one and three-quarter billion dollars a year. They pay out more than three billion dollars annually in wages. These large sums of money, passing into channels of trade and commerce, are factors of great importance in the maintenance of business activity. They furnish employment to hundreds of thousands of workmen; they turn many of the wheels of the nation's industries; they are passed on and on throughout the country's economic structure, until their direct and indirect benefits are felt by all persons.

Our railroads are still young and growing, in keeping with the youthfulness of our nation. They are not only adequate for present needs; they are capable of expansion to perform far greater service than can be provided with present facilities.

Railroad Capacity Increasing Intensively

In the early stages of railway development the growth of the railway plant was measured largely by the extension of mileage. But as time went on and the country settled up, the need was not so much for additional mileage as it was for increased facilities in the territory already occupied. Railway development in recent years, therefore, has consisted more largely of increasing the capacity and efficiency of mileage already in existence through the construction of second and other additional main tracks, the building of sidings and yards, the placing of heavier ballast, the laying of heavier rail, the reduction of grades, the elimination of curves, the installation of signal and other safety devices, the construction of more substantial and more durable bridges and structures, the enlargement of shop facilities and the purchase of more powerful and more efficient locomotives and improved passenger and freight equipment.

An indication of the intensive development of the railway plant is the record of what has happened to miles of road and miles of all track in the 10-year period ended December 31, 1924, the latest year for which complete figures are available. In that period, as a result of some lines being abandoned, the mileage of road owned decreased 3,786 miles, or more than the entire first-track mileage of some highly important railway systems. In the same period, however, the mileage of all railway track, including second, third and other main tracks, yard tracks and sidings, increased 23,958 miles, or more than the entire first track railway mileage in New York, New Jersey, and Pennsylvania combined. In other words, while the mileage of road owned was falling off about 1½ per cent in 10 years, the mileage of all track, which is more nearly a measure of total railway capacity, was increasing about 6¼ per cent.

In the four years ended December 31, 1925, the railroads of the United States installed more than 10,000 new locomotives, 9,300 new passenger cars and 619,000 new freight cars, replacing old equipment with new equipment that is bigger and better in every way and making definite advances in carrying capacity. In all, the railroads spent an average of more than three-quarters of a billion dollars a year during the last four years in improving and enlarging their facilities.

A Splendid Safety Record

The railroads have been making progress in the reduction of accidents and in the careful handling of freight. In 1920 they paid out approximately $220,000,000 for loss and damage claims, injuries to persons and insurance. In 1923 this was reduced approximately 50 per cent, to $112,000,000, and in 1924 to $108,000,000. Where these items represented 3.6 cents out of every dollar of total revenue in 1920, they represented only 1.8 cents in 1923 and 1924. This saving was due largely to increased diligence on the part of railway employees in safeguarding life and property. It is an indication of the increased efficiency which characterizes present day railway operations.

The railroads are becoming constantly safer for those who work on them and for those who ride their trains. Reports of railway accidents were first compiled on a national basis in 1888. In that year 315 passengers and 2,070 employees were killed. In 1925, 175 passengers and 1,523 employees were killed. This is a reduction of 45 per cent in passenger fatalities and a reduction of 26 per cent in employee facilities notwithstanding the fact that since 1888 railway passenger traffic has more than trebled, railway freight traffic has increased almost six times, and the number of railway employees is two and one-half times greater than it was then.

Highway crossing accidents, which are not included in the foregoing figures, have come in recent years to be the most prolific cause of fatalities on the railroads. This, of course, is due to the growing use of automobiles. However, the persistent efforts of the railroads to prevent such accidents through the education of the public and the vigilance of their employees are bearing fruit. In 1917 there were 22 fatalities in automobile accidents at grade crossing for every 100,000 automobiles in use, and in 1925 there were only 11 for every 100,000 automobiles in use, a relative decrease of 50 per cent. Because of the vastly greater number of automobiles in use in 1925, of course, the total number of deaths due to automobile accidents at grade crossings in 1925 was considerably greater than in 1917, and we must not let down in our activities.

There are 245,000 highway grade crossings on the principal railroads of the country. Some of these are being eliminated from time to time, but to do away with them all through the construction of subways and viaducts would require a generation of time and the expenditure of approximately 20 billion dollars, and that, of course, is prohibitive. The solution of the grade crossing problem must be found elsewhere. The best results will come out of our educational efforts. The railroads have taken the leadership in this safety program, and they should have thorough support.

The Automobile a Benefit to the Railroads

One of the comparatively recent developments in transportation is the tremendous increase in the use of motor vehicles on the highways. Railway progress has continued at a substantial rate in recent years, but nevertheless the increased use of automobiles and motor trucks has had its effect upon many of our railroads. In some respects that effect has been detrimental and in some respects beneficial, but if we could weigh the benefits against the detriments, I believe we should find that the railroads have gained a great deal more than they have lost from the development of highway transportation.

Long distance travel by railroads has continued to increase, but short distance travel has fallen off substantially, chiefly because of the convenience of the private automobile. It has become necessary for the railroads to discontinue the operation of many local passenger trains because of declining patronage.

As a connecting link between the railroads and off-line communities, the motor truck has been an aid rather than a detriment to the railroads, and the same is true of passenger carrying motor vehicles. Then, too, there is the vast amount of traffic which the railroads have derived from the handling of automobiles and parts, gasoline, roadbuilding machinery and so on. In that respect the development of highway transportation has helped the railroads.

The use of automobiles has created a new and gigantic industry and has given new strength to our entire economic structure. The automobile and the highway have helped tremendously to transform the living conditions, the thought, the culture and the very lives of the American people. That is what improved transportation always does. The development of transportation in its various forms has furnished energy for the progress of civilization throughout the centuries, and the rapid development of highway transportation during the last 25 years had been an extension of that progress.

The motor vehicle, of course, can never take the place of the railroad. Motor trucks will handle more or less short haul, package freight, but they will never handle any considerable amount of long haul, bulky freight, and the latter constitutes by far the larger part of the nation's commerce. The railroads are wholesale dealers in transportation; motor trucks are the retailers. The average carload of freight on the Illinois Central System consists of about 36 tons. It would require more than seven trucks loaded to five tons' capacity each to transport our average carload, and it would require 360 motor trucks loaded to five tons' capacity each and 360 drivers to transport the tonnage handled in a 50-car freight train. The total carrying capacity of the 2,400,000 motor trucks registered last year amounts to only 2.8 per cent of the carrying capacity of the freight cars owned by the Class I railroads of the United States.

The problem, as we see it, is one of co-ordinating the efforts of the two highly important branches of transportation. Both are performing essential service and there is plenty room for both. Where they complete, adjustment is needed. The fixing of rates, the taxation of highway common carriers in proportion to their use of the highways and other matters of like nature must in time be equitably adjusted so the railroads and motor vehicles operating as common carriers will be on equal footing.

In the meantime, it is to the advantage of the railroads to encourage the continued development of the highways and the increased use of automobiles. It is generally recognized that the railroads form, and will continue to form, the backbone of the American transportation system, producing a service that the country cannot get along without.

Developing Public Understanding

No one will deny that the railroads have made mistakes in the past. One of the costliest of their mistakes was their failure to discuss their affairs freely with their patrons. The well being of the railroads under private management, private ownership, private financing and public regulation is dependent on winning and holding the confidence and good will of the public.

The Illinois Central System has been active in educational work of this character. For nearly six years we have been publishing each month in the newspapers on our lines a statement discussing some phase of railway management and operation, and these statements, as many of you know, have had an excellent effect in putting the railroads before the people of our territory in an understandable way. We have discussed our affairs with the utmost frankness and candor and sought to correct such erroneous ideas and impressions as have been formed in the public mind regarding railway affairs. We have cultivated the friendship and enlisted the cooperation of our patrons and given them a better understanding and appreciation of the problems and conditions with which the railroads are confronted. We have taken the mystery out of railroading for them. There is, after all, no secret in the railway business which ought to be withheld from the public.

Satisfactory transportation service is ahead of all other considerations in railway operation. Service is the foundation on which must be built the structure of good will.

Words must be backed up by deeds. Educational efforts that are not backed up by good service are worse than useless. However, too many persons accept good service as a commonplace. It is difficult for them to visualize the vast expenditures and painstaking efforts which are necessary to produce good service. One of our duties is to tell them about these things.

The value of such a straightforward policy cannot be measured in dollars, but that it has been decidedly worth while is evident in many ways. Distrust, suspicion and opposition have disappeared, and in their place have come co-operation, friendliness and sympathetic understanding. As the result of work such as this the country over, confidence in private management was never greater than it is today. And with renewed confidence has come the gradual improvement of credit, which is so essential to the continued expansion and efficient operation of the railroads.

Improvements in Service and Efficiency

The last few years have witnessed a marked improvement in the service rendered by the railroads. The railroads today are performing more satisfactory service than ever before. Service is not only better, but cheaper. Measured in dollars and cents, rates at times in the past have been lower than they are now, but measured in terms of the service they buy and in terms of what money will purchase of goods and services generally, I believe rates never before have been as low as they are today.

The operation of heavier freight trains has made possible a great increase in freight traffic handled without a correspondingly great increase in the number of freight trains operated. Railway employment was steadier in 1925 than in previous years. The variation between extremes in 1925 was 95,000 men, compared with a variation of 190,000 men in 1923. The railroads recognize the important bearing which stabilized employment has upon business generally, and they are making progress in holding fluctuations of railway employment to the minimum.

That the railroads are handling their freight with greater care than ever before is attested by the fact that claims paid for loss or damage declined nearly 20 per cent in 1925, compared with 1924. Claim payments on account of delayed shipments in 1925 were nearly 43 per cent less than in 1924.

In 1925 new records were established in freight car miles per car day, in net tons per train, in gross tons per train, in freight cars per train, in freight train miles per hour in gross ton miles per train hour, in net ton miles per train hour and in fuel consumption per unit of both freight and passenger service.

What the International Railway Fuel Association Has Done

Fuel on the railroads is going farther today than ever before. Fuel consumption per unit of freight service was reduced 6.5 per cent from 1924 to 1925 and 19.3 per cent from 1920 to 1925. Fuel consumption per unit of passenger service was reduced 5.3 per cent from 1924 to 1925 and 14.3 per cent from 1920 to 1925.

On the basis of the traffic handled in 1925, the saving of fuel consumed in freight and passenger service in 1925 amounted to 24,467,000 tons as compared with 1920 and 7,302,000 tons as compared with 1924. The value of this fuel at 1925 prices was $73,400,000 for the savings under 1920 and $21,900,000 for the savings under 1924. These economies were due very largely to the more efficient and more scientific use of fuel.

The International Railway Fuel Association has been doing highly commendable work in the promotion of operating efficiency by its campaign for the economical use of fuel. Fuel is one of the largest items of railway purchases. The railroads consume annually more than 1,000,000 tons of coal. The locomotive fuel bill, consisting principally of coal, amounted to $437,000,000 in 1924, compared with $675,000,000 in 1920, a decrease of $238,000,000. Part of this reduction in cost is due to the lower price of coal, but a very substantial part of it is due to fuel economies that have been brought about by the railroads whose fuel experts are members of the International Railway Fuel Association.

I am proud to belong to the International Railway Fuel Association. It has made a splendid record in the comparatively few years the association has been in existence, and I look for it to continue to occupy an important place in American railroading.

Mechanical Factors in Fuel Economy

By C. E. Brooks, Chief of Motive Power, Canadian National

C. E. Brooks, chief of motive power, Canadian National, in a prepared address on this subject said that while to some of the older members the introduction of compounding might be considered as the first development to focus attention on fuel economy, to most men in railroad service today it would appear that the advent of the superheater about 16 years ago really marked the beginning of real thought in this direction. Following the superheater, Mr. Brooks called attention to the advent of the feedwater heater, the syphon and many other locomotive appliances. All of which these, he said, have tended to obscure the fundamental consideration in locomotive design for fuel economy; that is, sufficient grate area and sufficient boiler heating surface. Today, he said, there is a distinct movement to take full advantage of these factors accompanied by a disposition to develop the use of higher boiler pressures. The latter, he said, might ultimately mean a return to compounding.

Coal and Air Brake Charging

Among the mechanical factors affecting fuel economy, Mr. Brooks stressed the importance of suitable coal, the use of air brake charging plants in yards and other means of making it possible to have no terminal delays, which increase running speed and fuel consumption. He also pointed out that intermittent yard work is the cause of much fuel consumption, which points to the need of long runs to keep the amount of yard switching to a minimum. He called attention to the fact that in yard service 14 times as much fuel may be burned as would be required in road service to do the same amount of work.

Fuel Economy Devices

Mr. Brooks expressed the opinion that the line between the first cost and cost of maintenance of fuel economy devices for application to the steam locomotive and their value as measured in fuel saving, is nearly reached. If the same energy is devoted to the development of the internal combustion locomotive toward reducing the first cost, as has been displayed in similar developments in the automobile industry, there will be an immediate and great development wherever water and fuel conditions introduce heavy operating cost factors. He pointed out that even with doubled steam locomotive efficiency, it will still be less than one-third that of the oil engine in its present state of development, with the additional advantage of less standby losses and reduced fuel transportation and handling costs. This development, he said, can not be permanently deferred by opposition from any source.

In speaking of the part of the mechanical officer in the fuel economy program, he suggested that this officer should be listened to in connection with the selection of

fuel just as much as in the selection of the locomotive itself. Mr. Brooks expressed the opinion that had the mechanical officer's judgment governed in all cases in the past in the matter of the selection of locomotives, there would today be fewer underboilered locomotives in service. The mechanical officer, he said, may be depended upon to carry on toward better conservation of fuel.

Engineering Factors in Fuel Conservation

By H. R. Safford, Vice-President, Missouri Pacific Railway

There are five items in particular that, in my opinion, call for concentrated attention upon an engineering basis and which appear to have a field of great possibilities.

The first is the unit of performance that gives weight to the time element. I know this is a complex thing but it has much to do with the comparisons of use data. It has quite a definite bearing upon the economics of the design of main line from a capacity standpoint. Mere consumption per 1,000 gross ton miles without the measure of the time element will never permit a finished scientific treatment of the problem.

The economic speed of freight trains is, in my opinion, one of the least considered and one of the most important factors in fuel use. The tendency today is toward faster service. Our present competitive situation, which leaves service only as the argument for the expression of preference by the shippers, is placing speed at the top of the list of factors and if not given its true economic value may easily lead us into extravagance. On the other hand, however, the idle time of locomotives is a direct and wasteful leak. Our problem is to cut idle time rather than to increase speeds.

Train speed is a matter of great importance, not only in fuel matters but in other features of the economics of train operation. I believe here is probably the most fertile field for research, for much may be gained or lost by perfection or neglect of the value of this feature. The influence of rise and fall of speed is another important feature warranting the determination of co-efficients of comparatively easy application and of practical value. To do so will introduce much more intelligent handling of the economics of fuel use.

The long run is an engineering question of present day prominence with many evidences of success and it should be encouraged where the saving in engine hours and locomotive turning cost is greater than the burden of maintenance.

The pre-heating of locomotives from central plants is a subject of increasing importance and prominence. There can be little doubt of the fact that the saving in both time and expense is substantial. Against this, of course, is the investment and carrying charge of the distributing plant and the influence of the varying boiler load on a central plant.

It was thought, some years ago, that the development of the locomotive would be from steam to electricity, with central power supply. That was a perfectly natural thought and interesting examples of such a theory of development have been provided. Conversion of locomotive type from coal to some other power will generally be brought about by two major influences. One will be the requirements of civic betterment. The other will be the need for power economy. The first is economic in part only. The second is entirely economic.

Up to the present time, it seems to be well established that a complete substitution of central power supply electric operation is not universally desirable or practicable, that each substitution is an individual problem and that the application of the central power supply plan is quite limited.

The regenerative possibility seems to be an essential feature in the economic justification of the central power supply plan. In a study a few years ago, on a line with a heavy density of freight traffic, approximately 120,000 gross ton miles per mile of line during the peak movement, when units of 60,000 lb. tractive force had been provided, with a rating of 6,000 tons, and where coal could be obtained at cost it was found that conversion to electric operation, over a 160 mile district, would not yield in economic return more than half the interest. Yet, of course, where regeneration is possible an altogether satisfactory return is possible, as developed by the results on the C. M. & St. P.

For the great bulk of our railway mileage lies a territory without the regenerative possibility so it seems clear that some other method must be found to meet the economic demand, and there has come, in initial stages only, the combination oil-electric idea, with indication of considerable success. Its possibilities for answering the two major demands begin to appear. It is able to eliminate water supply, cinder and coal handling devices, stops for fuel and water, boiler repairs, turning expenses, including boiler washing, and a substantial reduction in machinery parts. These conditions would make great reductions in operating expenses of many classes. In civic betterment, which requires elimination of smoke, the idea, if it can be successfully developed, will solve the vexatious problem of interchange where that is a very great barrier to electrification.

Fuel conservation is not all a locomotive firing proposition. It is an operating problem, a maintenance problem and while, perhaps, there is not so much engineering science in the handling of locomotive turning, to minimize delays and waste of fuel, nor much of formulae and higher mathematics in keeping down steam leaks and wasteful practice in upkeep of property, there is just as much necessity for good, loyal effort in these as in any other phase of the whole subject.

Report on Front Ends, Grates and Ash Pans

The report of the committee this year dealt with the prevention of front end air leaks, the arrangement of ash pans, fireboxes and front ends of oil burning locomotives, and the use of grades with restricted air openings. In discussing the inspection of front ends for air leaks the report included several photographs of a locomotive, the front end of which was being tested by filling it with water through the stack, the tubes being plugged and the exhaust nozzle capped to make them water-tight. The extent to which water was leaking from the front end indicated that ordinary front end inspection methods are not as effective as they are sometimes supposed to be. The report also described a number of methods for preventing air leaks around steam pipes where they pass from the inside to the outside of the smokebox.

In the section of the report dealing with oil burning locomotives, the fact that cast steel fire pans are being employed to a considerable extent was recorded. It was also reported that the Atchison, Topeka & Santa Fe is eliminating arch tubes from its oil burning locomotives, and by the use of a larger stack having an integral inside extension it has been possible to open up exhaust nozzles by ¼ in. in diameter.

Last year the committee reported that in two railroads a radical departure had been made with respect to the total air opening through grates, which runs counter to the practice of securing the greatest possible air opening recommended by the committee. The A. T. & S. F., be-

cause of the waste due to fuel falling through the finger grates then in use, had changed to a table grate in which the individual air openings were greatly reduced. After the coal losses through the grate had been stopped, it was determined by means of gas analysis that more air than was required for proper combustion was being admitted, and the aggregate air opening through the table grates was reduced to as low as 16 per cent of the grate area. The committee also reported that the Northern Pacific, in trying to burn lignite coal, resorted to a similar practice, finally coming to a table grate with conical openings ½ in. in diameter at the upper grate surface, with the number of these holes such that the aggregate air opening was brought down to about 12 per cent.

This year, the report states, the committee in reply to letters, heard from 80 railroads on this subject, 55 of which have never deliberately restricted the grate opening, and 16 of which have reduced the size of the individual holes in the grates in order to reduce the loss of fine coal into the ash pan. In most instances, however, these roads have endeavored to keep the percent of air opening as large as possible, generally from 35 to 45 per cent of the grate area.

Of the other nine replies, four only indicate clearly that material reductions in aggregate air opening have been made, reducing it to a total of from 14 to 19 per cent of the grate area. The St. Louis-San Francisco resorted to the practice in attempting to burn different grades of slack coals in locomotive service and obtain good results with table grates having 25/32 in. conical holes and an aggregate air opening of 19 per cent, with the draft slightly sharpened. The Chicago, Milwaukee & St. Paul, in order to burn lignite coal where this is available, has found that by the use of restricted grate openings a reduction of from 15 to 20 per cent fuel consumption is effected. The Oregon-Washington Railroad & Navigation Company already burning sub-bituminous coal on a table grate having about 43 per cent air opening, experimented with grates having air openings of 14 per cent, but failed to find any advantage in this grate. The Temiskaming & Northern Ontario developed grates in which the total air opening was reduced to about 16 per cent of the grate area on an engine equipped with an exhaust governor. The road reports, however, that the tests did not show any improvement in fuel consumption of this combination as compared with the fuel consumption of the locomotive before the exhaust governor was applied and the grate openings reduced.

Northern Pacific Tests

The committee's report last year dealt at some length with the practice on the Northern Pacific where the grates with restricted air openings were developed as a part of the program to burn Rosebud coal, a Montana lignite carrying 25.66 per cent moisture and a heating value of 8,743 B.t.u. Since that time results of the tests of these grates have become available. These were represented by the committee in the accompanying table. The Red Lodge coal referred to in the table is a Montana bituminous coal bearing 11 per cent moisture and a heating value of 10,000 B.t.u. The Roslyn coal, a Washington bituminous, has about 4 per cent moisture and 12,000 B.t.u. The tests were made on a locomotive with 28 in. by 32 in. cylinders; a total weight of 320,000 lb., of which 240,500 lb. is on the drivers; 30,591 sq. ft. of evaporating heating surface; 838 sq. ft. of superheating surface, and a grate area of 70.3 sq. ft. It develops a tractive force of 57,100 lb. The grate for which the results are given in the first column of the table has a total air opening of 36 per cent of the grate area; that for which the results are shown in the third column of the table has a total air opening of 13½ per cent of the grate area.

In connection with the Rosebud coal, attention is called to its low heating value and also to the fact that a high stack loss results from its lightness and friability. The table shows that the Red Lodge coal gives the best results with the grate having the smallest air opening, whereas with the Roslyn coal the best results are obtained with the larger air opening.

The committee quotes M. A. Dlay, general fuel supervisor, Northern Pacific, as follows: "I can sum up in a sentence what may be the keynote to the improvement that we experienced with all kinds of coal on the grate having restricted openings. It is simply that the results of the tearing effect and higher rate of combustion possible with larger volumes and velocity of air through larger grate openings are not obtainable through grates having smaller openings. In other words, there is less clinkering tendency through the ability to control the air flow through smaller individual openings than there is through the larger openings, and since the excess oxygen which is present in the stack gases is about the same with the restricted or unrestricted air openings, the air supply is presumably sufficient, and, being controlled, produces less clinkering and permits the fires to be maintained in a proper condition with more ease."

TABLE SHOWING EVAPORATION OF ROSEBUD, RED LODGE AND ROSLYN COALS ON THREE DIFFERENT GRATES—NORTHERN PACIFIC

	Equivalent Evaporation, Pounds of Steam per Pound of Coal		
Kind of coal	On ¾ in. slotted grates	On ⅝ in. round hole grates	On ½ in. round hole grates
Rosebud	....	3.80	3.73
	....	3.95	3.82
	....	3.73	3.95
	....	3.93	4.00
	....	....	3.90
	....	....	3.74
Average evaporation	....	3.85	3.86
Relative evaporation	....	99.8	100.
Red Lodge	6.06	5.89	6.07
	6.14	5.69	5.78
	5.63	5.59	6.25
	5.70	5.85	6.07
	5.60	5.82	5.80
	5.71	5.92	6.07
Average evaporation	5.81	5.79	6.01
Relative evaporation	96.7	96.4	100.
Roslyn	6.51	6.61	6.01
	6.58	6.61	6.01
	6.34	6.64	6.39
	6.83	6.39	6.23
	6.69	6.77	....
	....	6.19	....
Average evaporation	6.59	6.54	6.28
Relative evaporation	104.8	104.1	100.

In concluding, the committee made the following statement: "It is obvious from this record that the Northern Pacific in setting out to burn lignite coal, had to carry a thin fire bed, that it had to reduce the size of the individual holes in order to avoid disturbing this thin fire, and apparently with the draft prevailing in these engines it had to decrease the aggregate air opening through the grate in order to avoid an excess of air. The question arises whether this excess might not have been avoided by decreasing the draft; that is, whether after reducing the size of the individual holes the aggregate air opening through the grates might not have been kept in the neighborhood of 30 or 35 per cent, and the size of the nozzle increased.

The report was made by a committee of which Prof. Edward C. Schmidt was chairman.

Report on Locomotive Economy Devices

The committee on New Locomotive Economy Devices this year reviewed briefly the various devices which are being closely studied by railways in order to institute fuel economies. The proper, intelligent application, use and upkeep of economy devices must be carefully investigated before logical conclusions can be made as to the over-all economy of such devices.

The feed water heaters, pump type, and exhaust feed water heater injectors, have previously been reported upon, and those installed and on order in America to date are as follows, as of May 1, 1926.

	Exhaust Steam Pump Type	Feed Water Heaters Injector Type
1920	7	..
1921	54	..
1922	234	..
1923	1,429	..
1924	2,123	24
1925	2,551	37

There have been no particular developments during the past year in feed water heaters of pump types, either open or closed, other than minor adjustments and corrosion studies.

The Elesco exhaust heater injector has increased in number the past year and has been described in full in the 1925 report. Reports still show an over-all saving, the same as previously given.

Sellers Feed Water Heater Injector

A new exhaust feed water heater injector has completed its experimental stage and is manufactured by William Sellers and Company, Inc., of Philadelphia.

In this system there is a simplicity of design and mechanical operation easily understood by engine men and applicable to the pooling system, the injector principle: a primary set of nozzles is operated by exhaust steam, utilizing the latent heat, and energy to deliver a strong and heated supply of water to a forcing set of nozzles, actuated by steam from the boiler; by those nozzles it is forced through the feed pipe into the boiler. This feed water heater injector reclaims the heat in the exhaust steam from the cylinders; and the heat in the live steam taken from, is also restored to the boiler, resulting in a final delivery temperature of the feed water which may be not far below the temperature of the steam.

The injector is operated by a simple cab stand mechanism. It consists of a lever acting through a link and extension rod, which opens, closes or adjusts the exhaust steam admission valve; a lever handle for opening, closing or adjusting a new form of water-tight, cylindrical lazy cock, a hand wheel for the final overflow. The method of manipulating the Sellers, "V. C." starting valve and cab stand levers, is similar to the Sellers Class K, non-lifting injector, so that it presents no difficulty or uncertainty to an engineer or fireman. The operator by the cab stand is entirely mechanical, consisting of a simple combination of levers, links and universal joints, for which repairs can be made by the ordinary railroad shop mechanic; there are no pneumatic valves or delicate pieces of mechanism. Exhaust steam is obtained from a bridge connecting the cylinders to a regulating valve; and is carried by a flanged pipe with easy bends to the injector, bolted to a bracket on the mudring on the right hand side. The regulating valve and its accessories include: a baffle plate to reduce the pulsations of the exhaust; a balanced piston valve to separate the injector exhaust supply pipe from the cylinders when the throttle is closed; if the injector is feeding while the engine throttle is closed; if the injector is feeding while the engine throttle is closed, this valve also regulates the quantity of exhaust steam to suit the requirements of the injector; an admission valve to substitute live for exhaust steam when the engine is standing or drifting. The operation of these devices is automatic. Within or directly in front of the cab is placed a duplex balanced lever starting valve V-C type, supplying the forcing set of nozzles of the injector, and to the live steam admission section of the regulating valve. In the cab is also placed the Sellers tell-tale or injector indicator, which clearly indicates to the engineer when the injector is operating, or if it happens to fly off, all without the necessity of watching the injector or its overflow from the cab window.

The Sellers system feeds the boiler with the same temperature of water when the locomotive is under load, standing, or drifting; its operation may be continuous, as the boiler feed is not interrupted by the above change of conditions. Owing to the small amount of live steam taken from the boiler and the unusual amount of heat in the feed water, the strain upon the boiler flues, the work required of the boiler, and the weight of coal consumed, are all reduced.

The injector is of simple construction, all nozzles may be removed and renewed without disconnecting from the locomotive.

Increased Boiler Pressure

During the last few years quite a number of railroads have utilized higher steam pressure on their locomotives. One railroad has over 500 locomotives which are using 250 pounds steam pressure, another road is now using the same steam pressure on a large number of locomotives, and still another road has now in service one locomotive which has a boiler carrying 350 pounds steam pressure, and this road is now contemplating the building of 25 more locomotives of the same design and carrying the same pressure. There is no question regarding the theory that increased steam pressure will give greater fuel economy. The amount of heat, and consequently fuel, required to raise the steam pressure from about 200 pounds (which is the usual pressure carried on modern locomotives) to 250 pounds, or 350 pounds, is comparatively small. The increase in power, however, by the use of this increase in pressure is very large. Therefore, a considerable increase in steam pressure is desirable as it will give considerably greater power with a very small increase in the amount of coal burned.

There are quite a number of details, however, which must be considered when a steam pressure higher than 200 pounds is used. One of the most important is the matter of boiler design. On the locomotives used by one road referred to above, and which carry 250 pounds steam pressure, the thickness of the plates in the boiler shell are $1\frac{1}{4}$ inches. Plates of such thickness are hard to shape into a locomotive type boiler and the weight of the boiler built of such plates is excessive. If higher pressure is used, much heavier plates would have to be used and it is a question as to whether it would be advisable to build a boiler of this type with higher pressures than about 300 pounds.

If the higher pressures are used, it will be necessary to resort to some different design of boiler, probably something in line with what was used on one road now having a locomotive carrying 350 lbs. steam pressure. This boiler should be considered as a semi-water tube boiler having a barrel at the front portion, but which barrel is very much smaller in diameter than the usual type locomotive boiler construction. We further believe that if higher

steam pressures are used it will be necessary to resort to an all-water tube type boiler.

Another detail matter to consider in connection with a higher steam pressure is the cocks, valves and fittings which will be necessary for use with this higher pressure. Manufacturers have developed standard designs which will safely carry steam pressures of 350 to 400 lb. If pressures higher than this are used it would be necessary to make up special designs for such cocks, valves and fittings. A large number of stationary boiler plants are now carrying steam pressures of 350 to 400 lb. and have utilized the standardized designs of cocks, valves and fittings. There are a few stationary steam boiler plants which have utilized steam pressures of 500 lb., and as high as 1,200 lb. These steam power plants, however, have had to resort to special designs of cocks, valves and fittings, and until these special designs have been thoroughly tried out and standardized, it would not be advisable to use steam pressures higher than about 400 lb. on locomotive boilers.

Still another point to be considered in connection with the use of high steam pressure is the advisability of the use of compound cylinders if steam pressures higher than about 250 lb. are utilized.

Greater Superheat.—Tests which have been made have indicated that there is considerable increase in economy by using a high superheat. However, there seems to be a limit to the maximum temperature, and this limit apparently is about 700 deg. If temperatures higher than 700 deg. are used, the troubles caused by expansion and contraction of the parts subject to this temperature, particularly the valves and cylinders, are considerable. The matter of lubrication at temperatures higher than 700 deg. is also a serious problem. Therefore, from a practical standpoint the limitations of temperature appear to be about 700 deg. F.

Auxiliaries Superheated.—This is a matter which has been given some attention during the last few years, particularly with the type of superheaters which use the steam throttle located between the superheater and the cylinders, instead of between the boiler and the superheater and which, therefore, keeps the superheater units filled with steam at all times when the boiler is under pressure. With this type of throttle, it is advisable to use superheated steam for all auxiliaries, viz., headlight turbine, air pump, stoker, feed water heater pumps, steam grate shakers, whistles, etc. Injectors, however, should use saturated steam. Tests which have been made indicate a saving of approximately 20 per cent of the steam utilized for those auxiliaries. Without the use of the front end throttle, however, it is difficult to utilize superheated steam as it would be necessary to provide some type of automatic arrangement whereby saturated steam could be used when the locomotive is not using steam. This has been done, but the necessary automatic values and fittings would be an additional expense and require considerable extra maintenance to keep them in a serviceable condition.

Locomotive Cut-Off Devices

The locomotive cut-off devices which are now used or are under development, and which should be considered by all concerned in line with fuel economy, are as follows:

Mechanical cut-off control consists of a reverse gear operated by back pressure from the locomotive. The piping is tapped into four exhaust channels, with a cut-out cock immediately back of the cylinders. The back pressure controls air valves, which, in turn, operate the power reverse gear. Located in the cab is a primary control valve operated by steam from the valve chamber, the pressure in valve chamber being sufficient to overcome the main reservoir pressure, and the valve is moved so as to admit aid to automatic cut-off control. The apparatus controls the cut-off in such a manner as to give the maximum efficient operation at various speeds and loads which the locomotive will handle.

Locomotive Valve Pilot

This consists of two parts, one a speed recorder and the other an attachment which indicates the position of the reverse lever. These devices are arranged in such a manner that they indicate on a duplex gauge the speed and the reverse lever position. For economical operation the hands on the gauge should coincide for all speeds and cut-offs. In other words, there is a definite relation between speed and cut-off and the manufacturers of this device claim to have worked out this relation to give maximum efficient operation.

Limited Cut-Off

This consists of a valve gear which is designed so that the maximum cut-off is limited to a point very much lower than has been the standard practice heretofore. This requires either an increased boiler pressure or cylinder diameter. Some locomotives have been built with a maximum cut-off of about 50 per cent and others have been built with a maximum cut-off of about 60 per cent. On account of the cut-off being shortened for all speeds the steam consumption is thereby reduced. Locomotives built so far to use the short cut-off have used the auxiliary ports to assist the locomotive in starting in low speeds. We believe, however, that a very satisfactory locomotive with 60 per cent and over cut-off can be built without these auxiliary ports.

Steam Chest and Back Pressure Indicating Gauges

This is essentially a back pressure gauge located in the cab, which indicates to the engineer whether his throttle is wide open and what the back pressure is in the exhaust chamber, from which he can determine the proper operating position of the reverse lever and in drifting can determine whether the cylinders have the proper amount of steam to prevent smoke and gases from entering them.

Fuel Economy as Affected by Cylinder Design and Arrangement

Cylinder design and arrangement as it affects steam consumption and, with it fuel economy, has brought out two recent developments which show improvements over the customary practice. These are the limited cut-off and three cylinder principles.

In the former, the engineman finds it impossible to operate at an extravagant rate of steam consumption at the lower and moderate speeds, because by the nature of the valve gear adjustment, cut-off in excess of a predetermined value is impossible of attainment. Coupled with this, we have the larger cylinder and the higher boiler pressure whereby to compensate for the comparative reduced mean effective pressure due to short cut-off at slow speed, the higher pressure itself being a factor conducive to fuel economy at any speed. The result is reported rates of steam consumption as low as 15.3 lb. per indicated horse power hour where a boiler pressure of 210 lb. per square inch was carried. This showing is contrasted with a minimum rate of 17.3 lb. per indicated horse power hour in the case of a locomotive of the usual full stroke arrangements, and whose boiler pressure was 205 lb., representing a saving of 11.6 per cent.

These figures, of course, represent the high water mark in the attainment of the two locomotives compared, and in neither case is the steam required by the auxiliaries

taken into account. However, since with the limited cut-off engine the water rates in excess of 19½ lb. per indicated horse power hour could not be exceeded, while with the full stroke engine, rates as high as 31.8 lb. per hour are recorded, it is seen that the limited cut-off engine with the higher boiler pressure showed a marked advantage in the economy throughout the full range of the test. A more complete elaboration of this topic is to be found in the proceedings of the New York Railway Club for November, 1923.

The three cylinder principle, highly developed and widely used in Central Europe and represented by upwards of 100 modernly designed and recently constructed engines in this country, offers a further definite step in the direction of fuel economy through reduction in steam consumption. This is, in a large part, a mechanical effect and is manifested in the form of more even torque on the driving axles, better adhesion, and greater facility in starting, all of which tends to improve machine efficiency. Under conditions of speed, the three cylinder engine shows an advantage over the two cylinder machine in consequence of lighter reciprocating parts and more perfect counterbalance, which also gives opportunity for improved steam consumption through ability to sustain drawbar pull at shorter cut-off.

Steam economy is further effected by cylinder design through resort to easy flowing passages on both incoming and outgoing sides and through precaution against pockets or recesses, into which the steam can flow with eddy current effect. Adequate precaution against condensation and facility for the draining away of such as does occur, are items which we sometimes find better understood than respected.

Pulverized Fuel

Pulverized coal for locomotive fuel remains a very live subject and with fireboxes and combustion chambers combined running 22 ft. in length in the new Union Pacific type freight locomotives, indications are that activity in this line should be noted in the near future, as the success of pulverized fuel is dependent to a great extent upon the firebox volume in order that the flue sheets be protected from the slagging action of the entrained ashes from the pulverized coal.

There are a great number of locomotive economy devices which your committee have not taken up; for example, locomotive boosters are considered by some as fuel savers where used on short grades, making it possible for increased tonnage ratings, thereby reducing the fuel on a thousand ton mile basis. Different territories, however, give such a wide variation of results that it can possibly be best handled by general discussion. The latest type of boosters which are applied to the four-wheel trailer trucks has been changed to 50 per cent limited cut-off from the original 75 per cent. This would further tend to make them a fuel saver.

The Committee presenting the foregoing report consisted of E. E. Chapman, chairman; E. A. Averill, W. G. Black, S. H. Bray, A. G. Hoppe, John R. Jackson, V. L. Jones, J. M. Lammedee, L. P. Michael, George S. Nickles, George E. Murray, L. G. Plant, H. W. Sefton and Prof. J. M. Snodgrass.

Authorize Large Capital Expenditures

In order that they may continue to provide for the growth and prosperity of the country and continue to furnish adequate transportation to the shippers of the United States under all conditions, Class 1 railroads up to April 1 of this year authorized capital expenditures for new rolling stock and other improvements amounting to $822,000,000, it was stated at a meeting of the Board of Directors of the American Railway Association held in Chicago on May 19.

This is based on replies just received by the Bureau of Railway Economics to questionnaires sent to all Class I railroads for the purpose of determining what capital expenditures have actually been made during the first quarter and what are contemplated.

Authorizations for capital expenditures made during the first three months this year exceed by approximately $60,000,000 those for the corresponding period last year.

Of the total amount authorized, $166,000,000 was actually expended for capital improvements during the first three months in 1826, which amount was slightly under similar expenditures for the corresponding period in 1925.

Of the $822,000,000 so far authorized, $467,000,000 represents unexpended authorizations brought over from 1925 while the $355,000,000 represents additional authorizations made during the first quarter this year. The Bureau estimates that the total capital expenditures for the year 1926 will run between $750,000,000 and $800,-000,000.

Comparing capital expenditures actually made during the first quarters of 1925 and 1926, it appears there was a decline in the total of equipment purchased, but all other classes of capital improvements showed increases.

Expenditures for Equipment and Engines

Capital expenditures made during the first three months this year for equipment amounted to $74,900,000, a decrease of $22,800,000 compared with similar expenditures for the first three months last year. Capital expenditures, however, for locomotives amounted to $18,300,000, an increase of $5,600,000 over the same period in 1925, although decreases, compared with the first quarter last year, were reported in capital expenditures for freight and passenger cars.

For roadway and structures, capital expenditures for the first three months this year amounted to $90,800,000, an increase of $19,200,000 compared with the first three months last year. Of the $90,800,000 expended for roadway and structures, $39,900,000 represented capital expenditures for additional track, heavier rail and additional ballast, an increase of $11,400,000 compared with the corresponding period last year. There also was an increase this year, compared with last, in expenditures for shops and engine houses and other improvements.

Largely as a result of the enormous expenditures the railroads have made in recent years for capital improvements, the rail carriers of this country during the first three months in 1926 operated with the greatest efficiency on record. Comparisons with 1923, 1924 and 1925 with respect to the majority of factors tending to show efficiency in operation, demonstrate a progressive improvement each year, with the result that the first quarter in 1926 exceeds all others. Notable improvement was made in the speed with which freight was handled by the railroads, there having been an increase of 10 per cent from 1923 to 1926 in the average daily movement of each freight car. Net ton-miles per train hour also show an increase of nearly 19 per cent in 1926 over 1923 while in fuel consumption in freight service, there was an improve- of nearly 22 per cent during the same period.

The progressive improvement in most of the factors pertaining to efficiency from 1923 to 1926 together with the fact that nearly all the items were at high level in 1926, indicates that the greater efficiency with which the railroads are continuing their operations is not a spasmodic movement, but is the result of a co-operative and sustained effort on the part of the railroads that continues day by day to contribute to the economic welfare of the United States.

With the increase in efficiency has come a decline in the cost of transportation to the public. As a result of this decline in charges for transportation, there has been a saving to the shipping public since 1921 of $2,344,000,-000. This is the total amount which shippers would have paid for transportation service in those years, over and above what they did pay, had the rates remained at the peak of 1921.

Rail carriers in 1921 received 1.275 cents for carrying the average ton of freight one mile. Due principally to reductions and readjustments in freight rates, however, that have been effected during the past four years, the average receipts per ton-mile have been dcreasing with the result that in 1925 they were 1.098 cents.

Report on Boiler Corrosion, Pitting and Grooving

By K. E. Fogerty, Before Master Boiler Makers Association

The Lines West of the Chicago Burlington & Quincy Railroad 5,000 miles of territory, have been doing everything possible that could be done in the way of treating water for low motive purposes, but still there is a great field for improvement in connection with pitting and deterioration.

On one of the divisions we have more or less alkali along the division, and while we have lime soda softening plants at different points, they do not reduce the alkali salts in the water, rather they increase them slightly. The untreated supplies of water on this division all contain rather high alkali salts, mostly sodium sulphate and carbonate of soda and magnesia. The pitting condition is mostly in our flues, and especially just inside the front flue sheet, causing deterioration and ringworming around the flues. Very little pitting has been found in the body of the flues on this division, but the condition mentioned has been practically eliminated by applying copper shims around all flues in the front sheet, allowing the copper to project into the boiler one inch. After these flues have given the required service, on being removed an inspection showed that there was no pitting or grooving in the location mentioned, so that all flues on this division are now being applied with the copper shims projecting into the boiler one inch.

On other dvisions we have pitting conditions the entire length of the flues, and generally on the top side these pits are deep enough to cause a defect. Usually a rusty like crust covers the pit, and when this is removed the clean metal is exposed as if acid action had taken place. On this division, and especially in the winter months, there is considerable alkali salts present in the water. There is no free acid in the treated water, but the alkali salts is mostly sodium sulphate and it has been observed that where alkali salts run very high, say 125 parts per 100,000, the pitting is greatly increased, and I must say that if it was not for the treated water on this division I doubt very much whether flues would give longer service than six or seven months.

On another division the mileage on flues is very good, and no trouble experienced from a flue pitting standpoint. However, the pitting on this division is confined to the top flange of back flue sheet and across the front of crown sheet, also on the lower sections of the combustion chamber. Up to the present time we have had very little pitting or corrosion on any of the boiler shell plates on any of the divisions mentioned.

The brand of material in use on the C. B. & Q. is standard for all boiler construction and repairs, but of late we have been experimenting with different grades of flues, such as steel and iron. However, I would like to mention that on the divisions where the most severe pitting conditions occur, especially on same class of power and operating on the same division, we do not find the pitting conditions of the same nature, for on some of this power we will receive 20,000 to 30,000 more more than we do on the others operating over the same territory.

May I also mention that while we treat our water for scale formation very successfully and we control foaming tendencies with a satisfactory anti-foaming compound, used by the enginemen, we face the destruction of the metal of our boiler through corrosion with apprehension.

We know that that kind of corrosion which is due to acids in the water is easily offset by the addition of alkaline chemicals; but we are facing something more difficult when we find pitting in waters already heavily alkaline.

Best authorities tell us that corrosion in the form of pitting takes place in alkaline waters, as the result of electrolytic action. This means that the water in the boilers acts as the electrolyte or the carrier for the currents between electrodes which are the different metals in the boilers; just as in the case of an electric battery.

It is understood that there are electrical contrivances which introduce counter electric potentials in these metals to offset the natural action, but it would seem simpler to change the chemical nature of the water, to prevent its acting as an electrolyte.

It is understood that to make a boiler water act as an electrolyte, certain impurities must be present. It is further understood that these certain impurities are magnesium salts, all nitrates, all chlorides, and sodium sulphate.

Many waters of the western territory carry all of these impurities, and practically all carry some of them.

Even the water from wayside treating plants, which is treated and settled, carries sodium sulphate, which is coming to be believed as the worst pitting impurity of all.

It is my understanding that another railroad has adopted this latter method mentioned above, with good success. Chemical compounds containing the necessary inhibitives are used through the engine tanks. The water, in both tanks and boilers, is kept charged, with the result that rusting of the tanks, as well as pitting in the boilers, is remarkably reduced, if not stopped.

If this is true, and I have no reason to doubt my information, we have the solution, and we should take advantage of it.

The road which I represent is about to try this method, and a report will be available later.

New Electric Locomotive for New York, New Haven & Hartford

The first of the new type electric locomotives for the New York, New Haven and Hartford Railroad has been shipped from the Erie works of the General Electric Company. The locomotive is one which combines the economic advantages of both alternating and direct current—alternating current for transmission and distribution, and direct current for operation of the traction motors.

Power is received from a single-phase trolley and, through the traveling substation carried by each locomotive, is reduced from 11,000 volts and 25 cycles to direct current at 600 volts.

The new type locomotive is a joint product of the American Locomotive and General Electric Companies. The New York, New Haven and Hartford Railroad is obtaining seven of them, five for freight service on the main line between Oak Point and New Haven, and two for switching purposes in general yard service.

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Railways and the Public

At the May meeting of the New York Railroad Club an interesting and able address was made by Mr. Charles Frederick Carter, the well known author and writer, his theme or text being the relations existing between the railways and the public, in the treatment of which he not only reviewed the past, but pointed out the favorable results obtained from efforts of public relations committees and bureaus to bring about a more friendly feeling and spirit of cooperation between the railways and the public.

In the discussion which followed, certain new angles of the question were introduced all tending to confirm the fact that "great changes had taken place," to the credit and mutual benefit of all concerned, and it is hoped that a still closer, more harmonious and mutually beneficial relationship may be developed.

In this question of public relations with the railways, it will be recalled that up until a few years ago, certain acts on the part of a few which really represented the worst form of disregard for truth, justice, and the rights of others, but which when seized upon, magnified and circulated by the professional anti-railway agitator was responsible for the almost general feeling against railways.

Too much credit cannot be given to those who have so successfully fought for a square deal for railways during past two decades, when many of our lines were, as the result of the most pernicious form of propaganda, on the verge of receiverships. Not a few were forced to seek the protection of the federal courts. Even men elected to high office not only allowed themselves to be used as willing tools in the hands of crooked agitators and politicians, but some of them took active part or leadership in a hostile campaign against the railways which resulted in impaired credit, loss of confidence of both the public and their employes and what might be termed a general orgy of destruction against railway interests, all of which was based on false premises.

Thanks to the awakened sense of justice of the electorate, some of the pseudo reformers have been relegated to obscurity where they properly belong, and instead of being important factors in shaping the destinies of a nation, they are just a plain cheap common garden variety of "politicians out of a job."

Railroad management now realizes that it is not enough to provide prompt, adequate and courteous service at low rates but to also lead an exemplary corporate life. Having done all this it is still as necessary constantly to remind the public of railroad virtues as it is to possess these virtues.

As Mr. Carter stated, "Now the law compels a ruthless revelation of the truth about railroads that leaves nothing to the imagination. But it is all for the best. Now that the public has been permitted to see the most intimate details of railroad financing, management and operation, suspicion has given way to friendly interest and cooperation. By no means the least of the benefits arising from open understanding openly arrived at between the railroads and the public has been the disappearance of that form of demagogy which manifests itself in hostility toward the railroads."

Transverse Fissures in Rails

Nearly a year ago there was a derailment of a passenger train on the Wabash Railway, that resulted in the death of one person and the injury of nine others. The derailment was caused by a broken rail and the rail broke because of an internal transverse fissure. The accident was investigated by the Bureau of Safety and Mr. James Howard, the engineer-physicist of the bureau, has issued his report. A report that is not at all reassuring. He discusses the development of this form of fissure, and says that the primary cause may be cooling strains or wheel pressures, but that, whether caused by one or the other, the situation is a disquieting one because of our "inability to prevent their recurrence, and" our lack of "knowledge of their existence in the track until some untoward circumstance reveals their presence." In short we do not know how to prevent their formation and are unable to detect them.

Six years prior to the accident under consideration the rail that caused this accident had been indented by a broken wheel, but the transverse fissure did not develope at the points of indentation but "in other parts of the rail, without relation to the indented sections."

The rail was broken into six short fragments between the fracture causing the derailment and the leaving end, and "incipient transverse fissures were displayed in some of them."

In discussing this phase of the subject the report calls attention to the opinion of some, that an incipient crack, possibly caused by cooling strains, is "the necessary antecedent condition for the formation of a transverse fissure." But "the formation of cracks signalizes that a partial relief from a maximum state of strain has been experienced by reason of the rupture of the metal." And it is the discontinuity of the metal caused by the crack that "locally intensifies the strains imposed by the wheel pressures."

We have no proof as to "whether a minute shrinkage crack was at the nucleus of a fissure, whether internal strains on the verge of rupture existed at that place, or

whether the inception of the transverse fissure was due solely to the internal strains set up by the wheel pressures."

There is an agreement that the growth of a transverse fissure is produced by track strains, that is whole loads; and the point of disagreement is as to the first cause. Was it a shrinkage strain or overstraining due to wheel loads.

The report seems to doubt whether the nucleus of a transverse fissure representing an area not exceeding one one-hundredth of the area of the head, and located "not among the fibers which are most remote from the neutral axis of the rail," could be responsible for the final fissure, especially since "the enlargement of such a crack would obviously demand a force nearly identical in magnitude to one necessary to start a crack in an intact rail."

It does not seem that this is a necessary corollary, for all engineers are familiar with the protentialities of a mere scratch, in a piece of metal subjected to reversed stresses, to extend and cause a final rupture in detail. There is something about a sudden change of section, however slight that change may be, that tends to a rapid and progressive increase of the difference between the adjacent sections. In other words, to the extension of the crack. So that it dos not appear to follow that because the crack in the head is small it will take as much force to extend the crack as it would to crack the solid head, any more than it would take as much force to convert a scratch at the edge of the wheel seat of an axle into a crack, as it would to start a crack in an unscratched axle.

As the report truly says, "the present situation is disquieting" because of its gravity. "It is the opportunity and duty of the users of rails to look diligently into the cause of the formation of this type of fracture. Efforts which have come to notice have contributed toward the elimination of probable causes. Positive data should now be looked for."

It is suggested that it is possible, if not probable, that these fissures are not due to a single cause, but are the resultant of two or more causes when a single cause is the source of an effect; it is usually comparatively easy to run it to earth. It is when a single resultant is produced by a multiplicity of causes that it is a matter of great difficulty to identify them. Probably if there had been but one cause for transverse fissures in rails it would have been detected long before this.

Railway Casualties Show Decrease

Casualties resulting from accidents of all classes on the railroads of the United States in the two months ending with February, 1926, show a decrease of 20 compared with the first two months of 1925.

In striking contrast to a decrease of 62 in the number struck or run over, not at public crossings, is an increase of 86 in the total casualties at highway grade crossings caused by the carelessness of automobile drivers. Grade crossing accidents show an increase from 702 in the first two months of 1925 to 899 in the first two months of the present year. The figures are compiled by the Interstate Commerce Commission.

Fifteen railroad employes on duty were killed in highway grade crossing accidents compared with four in the same period of 1925, or more than in most branches of train service.

A decrease of 55 train accidents in the two-month period as compared with the preceding year is shown by the report. This is a reflection of the increased efficiency of railroad operation which has included a more careful management of trains. Under train accidents are classed those resulting from collisions, derailments, locomotive boiler and other locomotive accidents. Casualties resulting from these accidents were reduced to 45 in 1926.

Train-service accidents, which include accidents at highway grade crossings as well as those from coupling or uncoupling trains, operating locomotives, hand brakes, getting on and off locomotives, etc., show an increase of 14.

Locomotive Efficiency Here and Abroad

To the Editor:

One of the important subjects now engaging the attention of motive power men, both at home and abroad, is the matter of locomotive efficiency. In the United States the application of aids to efficiency is the settled policy of mechanical departments, but it is of some interest to note that most roads are content with devices of proven worth like the superheater, and, perhaps, one or two others.

Some rather interesting results were obtained, however, by the simple expedient of varying proportions and details in the locomotives of an earlier period. Recent references to the Great Western Railway of England have brought to mind another useful 4-6-0 class on that line, as well as some American examples of the type with which it can be compared. I refer to the "Saint" class of two-cylinder single expansion 4-6-0 engines which still render very fine service on the Great Western.

Before proceeding further, however, it should be explained that, though many American railroads used the 4-6-0 type in fast passenger service, very few employed large driving wheels on it. The driving wheel diameter ranged from 68 to 72 inches, though occasionally a little above or below those limits. The most important of the roads which used large driving wheels on 4-6-0 engines were the Baltimore & Ohio Railroad and the Lake Shore & Michigan Southern Railway. The main characteristics of their large ten-wheelers may be of interest, as well as the engine numbers, which I have included for purposes of identification.

Baltimore & Ohio No. 1312, built by Baldwin Locomotive Works in 1896; cylinders 21x26 inches; drivers 78 inches in diameter; weight of engine, without tender, 146,400 lbs.; boiler pressure 190 lbs. per square inch; grate area 34.3 square feet; heating surface 2,160 square feet; tractive effort 23,750 lbs.

Lake Shore & Michigan Southern No. 602, built by Brooks Locomotive Works in 1899; cylinders 20x28 inches; drivers 80 inches in diameter; weight of engine, without tender, 171,600 lbs.; boiler pressure 210 lbs. per square inch; grate area 33.6 square feet; heating surface 2,917 square feet; tractive effort 24,990 lbs.

Both B. & O. 1312 and L. S. & M. S. 602 had wagon top boilers. The first engine of the class which subsequently became known as the "Saint" class (on account of the many engines in it named for saints) was built at Swindon Works of the G. W. R. in 1902. In due course, it received the name "William Dean," as a compliment to a famous Locomotive Superintendent of the line, who thereby joined the company of saints! This engine had a straight boiler with a Belpaire firebox, but the top of the barrel was considerably lower than the top of the firebox. In the course of time, this style of boiler was abandoned in favor of one having a conical connection between the barrel and the firebox. Finally, a standard boiler was designed in which the barrel was coned throughout its length; i.e., between firebox and smoke-box. The latter was much extended, in the style then favored in America, and still highly regarded by many roads. So now in service, this class has the following characteristics:

Cylinders 18½x30 inches; drivers 80 inches in diameter; weight not given in engine register, but comparable to that of American ten-wheelers mentioned; boiler pressure 225 lbs. per square inch; grate area 27.07 square

feet; heating surface 2,104 square feet; tractive effort 24,395 lbs.

Now, the first thing about this class which attracts the notice of an American observer is the very moderate cylinder diameter in conjunction with an exceptionally long stroke. The fact that batch after batch of these engines were built with such a long stroke and that speeds in excess of 80 m.p.h. were regularly attained by this class shows that the idea is practical, though not commonly approved.

Secondly, the high boiler pressure has made the class "smart" without excessive cost of maintenance.

Thirdly, to the same reason may be traced the very good tractive effort, notwithstanding the smaller grate and heating surface, as compared with the two American examples already mentioned.

Fourthly, the loads handled by this class are highly creditable to a two-cylinder engine of the type and dimensions.

At this point it may be pertinent to mention that Pacific type engines on the Great Northern Railway (U. S. A.) have a stroke of 30 inches in conjunction with 73 inch-drivers, and have given good service for many years.

It used to be thought that 24 inches made a long enough stroke for any passenger engine, even with drivers as large as 78 inches in diameter. Later on, 26 inches became the limit, and still remains so on some roads—fast ones, too! But the number of engines—of the Pacific type especially—with a stroke of 28 inches increases every year, mainly because the longer stroke assists an engine in starting a heavy train. And that is an important consideration with such loads as prevail in this country today. With regard to boiler pressure, the record shows that the "Lake Shore" engine was ahead of its times, as the figure of 210 lbs. was not retained on subsequent classes of the same general dimensions.

It may be of interest to note here that, when the "Twentieth Century Limited" was put on in 1902, the exceedingly handsome ten-wheelers, of the class to which I have referred, handled it west of Buffalo. I recall admiring these engines on the occasion of my first ride on the train in that year (eastbound).

The B. & O. engines were very "smart" and handsome, though my friend, Mr. Charles B. Chaney, could tell you more of them than I can.

We are using other types today, but great attention is being given to the important matter of proportion. Any locomotive builder will tell you that. Neither he nor I disparage the aids to efficiency which have been developed within the past decade or so, but it is only fair to give a good share of credit to the men who work out the chief details of design in such a manner that the completed locomotive will give the maximum of service with a minimum of trouble and expense.

In this connection, it is proper to observe that high maintenance standards constitute one of the prime needs of the hour. In England the first-class railways maintain their "power" very nicely, indeed. While it may not be possible to carry the matter of neatness to such lengths in this country, it should be easy to do a little better than some roads do. Certainly, it would pay, in the long run.

Before concluding these remarks it may be worth noting that the 4-6-0 has "won out" on the G. W. R. in competition with the Atlantic (4-4-2) and Pacific (4-6-2) types. There were at one time a number of Atlantics on the road, but all have been re-built as ten-wheelers, with the exception of three de Glehn compound engines which were purchased for experimental purposes, and are now assigned to light duties. There was only one Pacific ("The Great Bear") built at Swindon in 1908. After being in service for fifteen years, it was withdrawn and re-built in the style of the "Castle" class (4-6-0), retaining its number (111) but being re-named "Viscount Churchill," for the Chairman of the line.

Curiously enough, though the G. W. R. built the first Pacific type engine in Great Britain, it never built another. The larger amount of heating surface and grate area of the engine should have given it greater steaming capacity than the 4-6-0; but, as its tractive effort was not greater than that of the "Star" class, the design fell into disrepute.

All the same, if train loads increase much more, the Pacific type will have to be fixed, though every bridge from London to Penzance had to be re-built!

For the benefit of those who may desire to know something of the appearance of the "Saint" class, a photograph

South Wales Express—Great Western Railway of England

is presented herewith of "Lady of Quality" on an up South Wales express. Only part of the train is shown, but this helps in the presentation of a "close-up" view of the engine, itself. It will be seen that, with the exception of certain unmistakably English details, the engine resembles American practice; so far as general design is concerned, at any rate.

I may add that there are more than 75 engines of this class on the road, one of the "odd" ones being fitted with 72 inch drivers, experimentally; with a possible view to service on hilly sections of the line.

There are more than 70 engines of the "Star" class; and these, as before stated, will ultimately go into the "Castle" class, already rapidly growing.

Newton Center, Mass. ARTHUR CURRAN.

Roads Have Record Volume of Freight

The volume of freight transported by Class I railroads during the first four months was the largest for any corresponding period on record, the Bureau of Railway Economics reports. The traffic amounted to more than 148,000,000,000 net ton miles exceeding by more than 188,000,000, or by one-tenth of 1 per cent, the best previous record established during the first four months of 1923, compared with the corresponding period of last year the volume of freight handled this year was an increase of 6.2 per cent.

In the Eastern district freight traffic measured in net ton-miles showed an increase of 7.3 per cent in the first four months, compared with the corresponding period in 1925, while in the Southern district there was an increase of 11.6 per cent. The Western district showed an increase of 2.2 per cent.

Freight moved in April aggregated nearly 36,500,000 net ton-miles, a decrease of 5.2 per cent from the best previous April record, which was in 1923.

In the Eastern district freight traffic showed an increase of 8.3 per cent in April over the same month last year and in the Southern district there was an increase of 10.1 per cent. The Western district showed an increase of 7.2 per cent.

The Diesel-Electric Locomotive and Its Relation to Heavy Electrification

The Metropolitan Sections of four National Engineering Societies met in a joint session on the evening of February 18, 1926, in New York City, for the purpose of discussing the Diesel-electric type of locomotive and its relation to heavy electrification. The organizations represented were the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, and the American Society of Mining and Metallurgical Engineers. Addresses by engineers of recognized authority in their several fields dealt with the various angles of the problem, and considerable additional information of value was brought out in the discussion which followed. Extended extracts from the reports of the three addresses are given below. George J. Ray, President of the New York Section of the American Society of Civil Engineers, presided throughout the session.

The Diesel-Electric Locomotive and Its Various Applications

By HARTE COOKE, Chief Engineer, McIntosh-Seymour Corp., Auburn, N. Y.

The motive power best suited for any particular railway service is dependent entirely upon local conditions. The best way to get an idea of the effect of Diesel-electric locomotives on the electrification of steam railways is to look into the characteristics of the different types of motive power and the requirements of some of the special kinds of railway service, in order to determine the type of motive power best suited for the service.

Motive-Power Characteristics

As a standard of comparison the steam locomotive may be taken; its characteristics are as follows: Tractive-effort curve of maximum value, limited by the weight on the driving wheels; total weight on driving wheels limited by the loads permissible for a given track structure, also the number of wheels possible to use; maximum tractive effort maintained practically constant up to ten miles per hour, falling off approximately inversely as the speed thereafter, and approaching a hyperbola limited by the horsepower which can be developed by the cylinders and the boiler capacity of the locomotive. With this form of curve a locomotive can pull at considerable speed any load which it can start, the full horsepower being developed at high speeds only.

As a matter of reference, the weight of the steam locomotive with the tender may be taken as 100, and the cost likewise. The horsepower output is limited by the size of boiler accommodated by the usual railway clearances, it being possible to arrange a sufficient number of axles to keep the axle loading within permissible limits. A tender must be supplied to carry fuel and water. The fuel cost may also be taken as 100. Provision must be made to replenish the water and coal supplies; the ash pan must be dumped and the ashes taken care of at frequent intervals; the boiler must be cleaned at certain longer intervals, and the entire locomotive repaired from time to time, all limiting the time in service. One effect of getting maximum output with a minimum of weight is to reduce the time available for road service. The actual service time may be taken as 100.

The Diesel-electric locomotive is able to develop its full horsepower at any speed, which, with the even torque of the electric motor, gives a high tractive effort as starting, the weight being such that practically all of this can be utilized.

The tractive effort is generally inversely as the speed, the curve being approximately a hyperbola equivalent to the net horsepower, giving the locomotive the ability to easily start any load it can draw at a reasonable speed, and to accelerate rapidly. The Diesel weighing about 50 per cent more per horsepower than the steam locomotive, the weight may be taken as 150. The cost being about three or four times that of the steam engine, may be placed at 300 or 400. The maximum output can be arranged as desired, since multiple-unit control is possible with such equipment.

It being possible to carry the fuel and water on the locomotive and eliminate the tender, and allowing for there being no stand-by losses, the fuel cost may be taken as 30 as compared with steam.

Regarding care, only a small amount of fuel and water are required at infrequent intervals; no boiler cleaning is required; and usual traffic conditions will allow the limited repairs required by both Diesel and electrical equipment. The time in service will be represented by 200, or twice that of the steam locomotive.

The tractive effort of an electric locomotive, the curve of which approaches a straight line, is limited by the weight on the driving wheels, falling off as the speed increases; but the usual changes in connections of the motors as the speed increases bring the tractive effort from time to time near the original value. This form of tractive-effort curve not only gives high accelerations at starting, but also high speeds with heavy trains, the motors being able to use a large amount of actual power at high speeds.

The weight bears a certain relation to the tractive effort desired, and if the arrangement is such that all the weight is on the driving wheels, the electric locomotive will weigh less per horsepower than a steam locomotive. The weight may be represented by 75.

The locomotive itself might cost about the same or considerably more than the steam locomotive, depending on the arrangement. In any case, however, this cost has to be considered in connection with the cost of the power house and transmission system, and, in general, may be represented by 300 to 600.

Considering the losses in the transmission system and the known results from central stations, the relative fuel cost may be taken as 37.

These locomotives can be arranged for multiple-unit control, so that any output desired can be obtained. All equipment necessary for operation is on the locomotive, no tender being required.

Regarding care required, the locomotive does not have to stop for water or fuel, and the care required amounts to the usual periodic inspection and maintenance of running gear and electrical equipment, all of which can be done during idle periods due to traffic conditions, enabling the locomotive to be in service over twice as much time as the steam locomotive. This time may be represented by the figure 225.

Tabulated, the approximate relative values appear as follows:

	Locomotive		
	Steam	Diesel Electric	Electric
Weight per hp.	100	150	75
Cost per hp.	100	300 to 400	300 to 600
Fuel cost per hp.	100	30	37
Time in useful service	100	200	225
Maintenance	100	75	50

Requirements of Some Classes of Railway Service

The conditions to be met in this case are very heavy traffic, a great number of stops, strict maintenance of schedule, and maximum acceleration at starting with minimum discomfort to passengers, requiring tremendous power capacity for a train with the minimum weights carried. Further, there must be no objectionable gases in the stations, the maximum power requirements are for but short periods of acceleration, and a large number of trains per mile of road results in a large power requirement per mile. These conditions eliminate the steam locomotive at once.

The Diesel-electric locomotive is suitable so far as the tractive-effort curve for high acceleration is concerned, but the weight added to the train would increase the power necessary to give the desired acceleration. The maximum power being required for but short intervals, the average power would be low, with a high investment based on the maximum demand. The gases would be objectionable. The fuel cost would be moderate.

For full electrification the tractive-effort curve is the best that could be had for maximum accelerations. With motors on the passenger cars the weights would be at a minimum, resulting in maximum acceleration with a minimum of power. There would be no gas and a minimum of heat would be liberated. The maximum of power being required for acceleration only, the effect of the diversification factor results in a minimum power-station cost, and the high traffic density per mile of road will reduce the relative cost of transmission lines and third rail. Power generation in an efficient power house will result in low fuel cost. Balancing the operating results against the capital investment necessary gives the following figures:

Using a Diesel-electric locomotive, the weight of the train would increase 30 per cent, requiring 30 per cent more power to give a certain desired acceleration, the relative cost of the locomotive then being $1.30 \times 300 = 390$. With motors on the trucks the weight of the train would be increased about 10 per cent, the relative cost then being $1.10 \times 300 = 330$. The diversification factor might reduce the size and cost of the power house one-third, which would reduce the capital cost for electrification by about one-half of this amount or one-sixth, showing finally five-sixths of 330, or 275, and indicating a lower capital cost for electrification. The fuel costs would be $1.3 \times 30 = 39$ for Diesel power and $1.1 \times 37 = 40.7$ for electrification, indicating a saving too small to justify the increased capital cost of the Diesel-electric installation.

Heavy Suburban Service. This service closely parallels that of the subway, with the exception that the traffic is not so heavy. Assuming that the traffic is about 50 per cent of that in the subway and the distances between stations greater, the relative costs would be as follows:

The steam locomotive would add 20 per cent to the train weight so for a given acceleration the capital cost would be 120 and the fuel cost 120. Due to the nature of the tractive-effort curve, the Diesel-electric locomotive would show a reduction of 10 per cent in horsepower, the cost then being $0.90 \times 1.30 \times 300 = 350$. The fuel cost would be $1.3 \times 30 = 39$. Third-rail and transmission lines coupled with the use of a locomotive instead of motors on the trucks would show for the electrified line a first cost of $1.2 \times 400 = 480$. The diversification factor, on account of the lighter traffic, would amount to about 20 per cent, and the power house would be a smaller part of the total investment, reducing the capital cost by about 7 per cent and resulting in the figures $0.93 \times 480 = 455$. The fuel cost for the electrification would be $1.2 \times 37 = 44.4$.

The first cost and relative fuel costs would work out as follows:

	Steam	Diesel-electric	Electric
Cost	120	350	455
Relative fuel cost	120	39	44.4

Taking the use factor the above would be modified as follows:

Cost	120	175	202
Relative fuel cost	120	39	44.4

Assuming an annual fuel cost for the steam locomotive of half its first cost, then the fuel bill for the Diesel-electric locomotive would be $(39 \times 0.5)/120 = 16$ per cent of the first cost.

The annual saving of 34 per cent of the locomotive first cost would more than justify the extra capital cost shown for the Diesel-electric locomotive for the suburban traffic.

In heavy main line traffic there is some advantage of of the diversification factor, although not nearly so pronounced as for the suburban and subway traffic.

There will be a heavy traffic density, also large amounts of power will be required to maintain the high speeds necessary to get the maximum capacity out of the line, especially if the grades are heavy.

For these conditions the lesser value of the diversification factor requires a much larger power house with a greater capital expenditure for electrification. The heavy traffic density, however, reduces the cost and losses in the transmission line. Accelerations do not figure to any great extent, it being more a matter of horsepower.

The steam locomotive would add about 20 per cent to the weight of the train, so the capital cost would be 120 and fuel cost 120.

For the Diesel-electric locomotive the form of tractive-effort curve would not help. On level track the 30 per cent added weight does not deduct 30 per cent from the performance, so the capital cost will be $1.3 \times 400 = 520$, and fuel costs $1.3 \times 30 = 39$.

For full electrification the electric locomotive would add 20 per cent to the train weight, making the capital cost $1.2 \times 400 = 480$, and the fuel cost $1.2 \times 37 = 44.4$. The diversification factor would be small, about 10 per cent, which might reduce the capital costs by 5 per cent, making it $0.95 \times 480 = 455$.

A tabulation of these figures follows:

	Steam	Diesel-electric	Electric
Capital cost	120	250	455
Relative fuel cost	120	39	44.4

On account of the greater useful time with the Diesel-electric, the above figures change as follows:

Capital cost	120	260	203
Relative fuel cost	120	39	44.4

From these figures it can be seen that full electrification would justify the increased capital costs.

In the case light main-line traffic of trains are infrequent, traffic, density light, and high-speed schedules may not be required. On account of light traffic, no benefit is obtained from the diversification factor. A relatively large amount of transmission-line and overhead or third-rail work is required. The following figures apply to this service:

Steam operation: capital cost, 120; fuel cost 120

Diesel-electric operation: capital cost, 520; fuel cost, 39. Full electrification, on account of the long distances, would be 1.2 × 500 = 600 for capital cost, and 1.2 × 37 = 44.4 for fuel cost.

The figures are tabulated below.

	Steam	Diesel-electric	Electric
Capital cost	120	520	600
Fuel cost	120	39	44.4

On account of the use factor these would be as follows:

Capital cost	120	260	267
Fuel cost	120	39	44.4

The above saving in fuel would justify Diesel-electric operation. However, in some special cases with heavy grades to increase the capacity of a single-track line to save the cost of double track, complete electrification would give the large amounts of power available for each train, so that faster schedules on grades would result and the capacity of the line would thereby improve. Also, in this case, regenerative braking is advantageous. These might justify complete electrification.

Long Branch-Line Service usually have relatively light traffic, do not require fast schedules, and would not justify the expense of electrification. Passenger traffic could probably best be handled by Diesel-electric rail cars and the freight by steam locomotives.

Short Branch-Line Service traffic would ordinarily be light and no fast schedules required, and therefore such lines would be unsuited for complete electrification. Special cases of heavy suburban traffic and connection with electrified main lines might justify electrification. However, for light passenger traffic the gasoline rail car is to be preferred, the Diesel-electric car for heavier traffic, and steam locomotives for freight haulage.

Electrification is not suitable for switching service owing to the small power requirement, low power factor, and expensive third-rail and overhead-work installation and maintenance.

Figures for steam would show a capital cost of 120 and a fuel cost of 120. Switching speeds being low, advantage could be taken of the Diesel-electric locomotive tractive-effort curve, permitting the use of 50 per cent of the steam-locomotive horsepower. The following figures would result: Capital cost, 0.50 × 1.3 × 300 = 195; fuel cost, 1.3 × 30 = 39. Full electrification would reduce the horsepower 50 per cent, but the overhead work would be greater, bringing the figures up to 0.50 × 1.2 × 600 = 360 for capital cost and 1.2 × 37 = 44.4 for fuel. These figures with the use factor, less than usual, included, are tabulated below.

	Steam	Diesel-electric	Electric
Capital cost	120	120	210
Fuel cost	120	39	44.4

The fuel saving, although small, coupled with the absence of smoke and noise and the elimination of ashes, coaling and taking on water, would more than justify the increased investment of the Diesel-electric installation.

Conclusion

Summing up, light freight and through passenger traffic can best be handled by the steam locomotive, with gasoline rail cars for local passenger service. Conditions should be carefully analyzed to determine the proper time for supplementing steam locomotives by Diesel-electrics. Full electrification should be used for heavy traffic, since it has been shown that it gives dependable service at a low fuel cost. The Diesel-electric locomotive is not suitable for subway service, owing to the gases, to traffic conditions requiring great numbers of stops, and to the extra power required for accelerating the extra heavy equipment. Steam is also out of question here because of the gases, leaving full electrification as the only solution.

Oil-Electric in Switching Service on the Central Railroad of New Jersey

Advantages of the Oil-Electric Locomotive Over Electrification on Short Line and Switching Operation

By C. H. STEIN, General Manager,
Central R. R. of New Jersey

The first steam locomotive to be operated in this country weighed but 8 tons as compared with the latest locomotive of that company, which weighs 273 tons. The

tractive power of the former was but 2000 lb., while that of the latter was 104,000 lb. The efficiency of the latest design was 52 times that of the 8-ton engine. Prior to 1900 there were but few improvements in the steam locomotive, the greatest development occurring during the following 20 years.

The multiplicity of parts likely to get out of adjustment was one of the great problems in the steam locomotive, since much valuable time was lost through shop repairs. Owing to the fact that additional improvements meant additional apparatus to be repaired, he felt that the steam locomotive could not be expected to show further great improvement. The slow improvement in the applications of steam with those of electricity, mentioning the steps from the first cable street cars to the electric cars and buses in general use.

Many considered the new Diesel-electric locomotive to be an infant prodigy, from which no one knew just what to expect, but which every one seemed to feel would eventually show worthwhile results. The early forms of gasoline engines had been looked upon in much the same way, but the forced development of the World War period had produced engines suitable for a multitude of purposes.

The question had often been asked when the Jersey Central lines would be electrified. For over ten years I have felt that a satisfactory form of self-contained electric or gas-electric car would be developed which would make the great expense of electrification unnecessary. The economy of electrification was not sufficient to overcome its high first cost. This fact probably accounted for the slowness with which electrification was proceeding. Another obstacle was the high cost of motive power. The third rail or overhead wires were not desirable from the standpoint of safety, and tie-ups often resulted from sleet and ice on the rails and wires. Further, trouble in the power house affected the entire operation.

A further objection was the necessity for supplying means for meeting the peak power demands encountered only on special occasions, the remainder of the year requiring but a part of that peak demand.

Many short lines interchanged traffic with other lines, a practice likely to result in difficulties under electrification, owing to the fact that it was not an easy matter to induce different companies to view the situation from the same standpoint. This condition, had caused great difficulty in the matter of automatic train control, and the problem of electrification would be harder to solve.

The first oil-electric locomotive to be operated in the vicinity of New York City for switching service was the product of the General Electric, American Locomotive, and Ingersoll-Rand companies, and had been operated in the Bronx terminal of the C. R. R. of N. J., since the latter part of last year, where it had been thoroughly tested under severe conditions.

Some of the advantages of such a locomotive were as follows: It was a self-contained unit; the power was generated and applied within this single unit; disturbances on the line would not affect the ability to produce power; a heavy investment was not required to meet peak power requirements, it being only a question of the number of units and their sizes. A further advantage lay in the fact that changes from steam power could be made gradually, new locomotives of the new type being added as the power demands were made or as old equipment was scrapped. Experiences in snow storms and blizzards indicated that less trouble was to be expected from the oil-electric locomotive than from other forms of power.

There were reasons for believing that the oil-electric locomotive had a greater thermal efficiency at the rim of the driving wheel than any other form of power used.

The reasons leading to the adoption of the oil-electric locomotive for the Bronx terminal had resulted from a very thorough investigation in which the advantages of various forms of electrification have been considered and their relative costs, etc. weighed. In this particular case it has been found that the advantages of the oil-electric locomotive for switching purposes indicated that it would give the best service for the conditions at hand.

General Discussion

Edwin B. Katte[1], who opened the general discussion, said he felt that the Diesel-electric locomotive would act as a stimulus to electrification, for, with its use to any considerable extent, the cost of electric locomotives would be likely to drop.

He mentioned switching as the most promising field for this type of locomotive, or service between yards operated under different systems of electrification. Another field mentioned was branch-line service with light traffic. It must operate with a minimum of noise, however, and with no smoke, and the economy in operation must at least equal that of the electric locomotive and the first cost be less than the combined cost of the electric locomotive and the working conductors.

The ultimate cost of the unit, Mr. Katte said, was a grave question. He felt that the price should be greatly reduced, and explained that it was with the hope that mass production would produce the desired result that trial orders had thus far been awarded. Also, he said, the economic advantage must be definitely established. He mentioned two orders placed for locomotives weighing over 100 tons each. A passenger locomotive weighing 148 tons was to be equipped with a Diesel engine of 800 hp. It was designed for main-line light passenger service. A freight locomotive weighing 128 tons was to be equipped with a 750-hp. engine. The passenger locomotive was designed for a maximum speed of 60 miles per hour and the freight locomotive for 40 miles per hour. The usual speed of the passenger type would be between 15 and 50 miles per hour, and between 8 and 35 for the freight.

W. B. Potter[2] felt that the electrical form of power transmission for the Diesel locomotive was the most desirable form available. The ease with which the engine could be replaced by an overhead wire seemed to him to be in favor of electrification as traffic conditions changed.

The many places in which the motor car and Diesel-electric locomotive would be found advantageous would, in most cases, be found to be those places which, at least under the present state of development, would not be found at all favorable for electrification. In so far as the use and operation of such equipment tended to extend the use of electric motive power, it was going to be beneficial toward electrification.

It would be perfectly obvious that the engine on the car or locomotive could be replaced by an overhead wire and supplied from a power station without involving anything very new; and familiarity with that type of equipment would certainly have an effect favorable to electrification rather than otherwise.

For such service the Diesel-electric locomotive had the advantage in that it could be equipped with duplicate motive power, and in that way maintain a better road factor than would be possible if a single engine of twice the size were used.

The possible return on the investment was considered the determining factor in the selection of types of locomotives for the various services encountered. The conditions under which the engine was forced to operate made it necessary to carefully study the design with respect to weight and reliability of service.

Mr. Potter also touched upon the desirability of the Diesel locomotive from the standpoint of maintenance, fuel economy, and thermal efficiency, agreeing with the other speakers on this point.

Sidney Withington[3] referred to the years of development back of the steam and electric locomotives, and mentioned the lack of data upon which to base maintenance figures for the Diesel-electric type of locomotive. The first cost, he felt, would be reduced considerably as production increased.

Commenting on full electrification, he said that its reliability had been demonstrated to be far greater than that of steam.

He felt that standardization would help greatly to clear up much of the confusion surrounding electrification systems. Personal safety was largely a matter of education, and would improve as experience was gained. The cost of electric and Diesel-electric locomotive power would also drop as time passed, he believed. He referred to the railroad strike of 1922 as an example of the ease with which service could be maintained with electric locomotives, the labor required for maintenance being of a less skilled nature than that required for steam locomotives. He felt that the same could be said to exist, to a certain extent, in the case of the Diesel-electric.

Mr. Withington, as did the other speakers, referred to the importance of carefully considering the problem before deciding upon the type of locomotive. He agreed that it would be impossible to use the Diesel-electric type in subway service and for heavy traffic, the extremely heavy trains in some cases requiring more power than could possibly be generated in one unit. In dense traffic the cost of the locomotive would be excessive.

As an indication of the diversity factor obtained by electric operation, he mentioned a road on which the aggregate horsepower represented by the locomotives was more than four times the capacity of the power plant.

If the motive power in this case were changed to Diesel-electric locomotives, he pointed out, the aggregate cost would be practically twice that of the entire electrical system, including power plant, transmission and distribution system, and electric locomotives. In addition there would probably have to be greater terminal facilities for refueling the Diesel locomotive, and additional engine houses to effect repairs on account of the added complications. Transmission-system maintenance costs would amount to a very small figure, comparatively, in extensive electrical systems.

Another point raised was the possibility that the great demands for oil as a fuel would change the economic status decidedly. In this case the central station, which could be made to burn any type of fuel, might show the greatest advantage, Mr. Withington said.

Another point of application of the Diesel locomotive, not mentioned by the other speakers, was for work trains, particularly wrecking trains, where the constant losses for steam equipment were a large proportion of the total fuel consumption. The electric locomotive would not be suitable for such service, because of the necessity of operating with a dead rail at times. The deciding factor in selecting the type of motive power was the probable density of traffic per mile of track.

J. G. Dudley referred briefly to the results possible through careful attention to the steam locomotive. He mentioned a plant built by Hiram Maxim, which was of 360 hp. capacity and weighed but 6 lb. per hp.

[1] Chief Engineer, Electric Production, New York Central Lines. Mem. A.S.M.E.
[2] Chief Engineer, General Electric Co., Schenectady, N. Y. Mem. A.S.M.E.
[3] Electrical Engineer, New York, New Haven & Hartford R.R., New York, N. Y.
[4] Consulting Engineer, Murray & Flood, N. Y. City.

The work of the late Dr. Diesel was referred to by H. H. Suplee, who said that in 1912 a Diesel-electric locomotive had been built in Switzerland by Sulzer Brothers, but the development stopped because of Dr. Diesel's death and the World War.

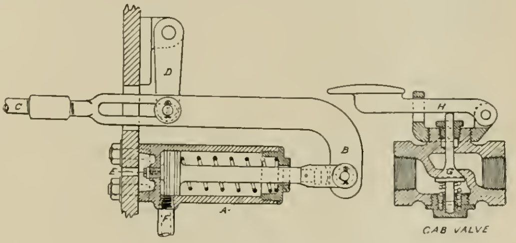
W. S. Murray[4] said that the answer to economical transportation lay in the annual charge for that transportation, which was divided between the fixed charges made up of interest, insurance, depreciation, and taxes upon the new property created to perform that operation, and the annual operating expense.

He, too, felt that the field of the Diesel-electric locomotive would be in yards, on branch lines, and possibly on light traffic on main lines, but never on heavy main-line traffic.

A Whistle Air Valve

A convenient air valve for sounding the whistle on locomotives has been brought out by the Gustin-Bacon Manufacturing Co. of Kansas City, Missouri. Its operation and construction is very simple as will be seen from the accompanying engravings. It can be used independently of the manually-operated levers and in no way interferes with the use of the latter. It consists of a cylinder *A*, having a bore 2 in. in diameter and an inside length of $3\frac{1}{2}$ in. In this there is a piston acting against a retracting spring and, through its piston rod, on a bent connection *B*, that is, in turn, fastened to the whistle pull rod *C*. Air is admitted back of the piston through the pipe *F*.

In the connection *B* there is a slot for the play of a



Air Valve for Operating Locomotive Whistle

case-hardened pin on the lower end of the manual operating lever *D* so that it can move and open the whistle valve without affecting the lever *D*. When the whistle is to be sounded by hand the lever is moved and the pin and its lower end strikes against the end of the slot, moving the connection *B* to the right and opening the whistle valve.

The cab valve is little more than a spring closed, hand operated check valve. The valve *G* is held against its seat by the spring beneath it and is opened by the lever *H*, pushing down upon the stem above that passes through a stuffing box. The operating end of the lever is fitted with a pad $1\frac{3}{4}$ in. in diameter, by which it is depressed.

After the whistle has been sounded and the cab valve allowed to close the air in the cylinder *A* escapes through a small hole drilled in a $\frac{1}{4}$ in. pipe plug *E* that is screwed into the back head of the cylinder. There is a leakage through this hole during the time that the whistle is sounding, but the loss of air is so slight as to be negligible.

The device is here shown as bolted to the inside of the cab wall, but it can be placed in any other convenient location. The piping used for the air connections is $\frac{3}{8}$ in. diameter.

Shop Kinks

Some Handy Appliances Used in Railroad Shops

Removing Cores

The entire removal of cores from small castings is, sometimes, a good deal of a job, and tumbling does not always do the work satisfactorily. Here is an idea that is worth trying as, in one place at least, it is working successfully. It should be added, however, that it is only applicable to brass. Before the casting is quite cold dip it into water, and the steam formed on the surface of the metal will blow off every particle of sand and leave the casting as fresh and clean as though its interior had been made into a tumbler and run until it was worn bright. But it will not do to be careless in the handling, because, if the metal is plunged in too hot, it is apt to be softened or cracked; but, after a short experience, the scheme can be worked as a great labor saver. The man using it would handle his piece about as rapidly as the ordinary laborer could be prevailed upon to throw them into a tumbler.

Cleaning Deep Holes

Steam can also be used advantageously for blowing chips out of a deep hole. In one case where some ¾ in. holes had been drilled to a depth of 12 in., the cleaning with a worm and waste was an almost impossibility, but with a blast of steam from a 3/16 in. nozzle run down to the bottom of the hole the work was done in about thirty seconds. Steam was used, in this case, because no compressed air was available, but the latter would have been more satisfactory, since it makes no sloppy muss.

In reference to this matter of cleaning deep holes, it is well known that, when they are being drilled, the drills sometimes break off short, and this is very apt to occur when the hole is nearly finished, and the piece broken off will be wedged into the hole in the tightest possible manner. The holes above referred to were drilled with home-made flat drills and breakages were not uncommon, and it was impossible to pull them out, but a resort to gun powder did the job. Enough rifle powder was poured into the hole to cover the piece, first running a fast burning fuse down to the bottom of the hole. Then about two inches of paper was rammed down over the charge and the thing touched off. There was a report, a scattering of coal in the bin towards which the improvised gun was aimed and the broken end of the drill was lost to sight forever.

This is a rather primitive adaptation of the gun used extensively at one time for driving out bolts, and which may be still in existence. The first of its kind is believed to have originated in the Susquehanna shops of the Erie Railroad. There as elsewhere it was not only not unusual but the rule that the bolts driven in to hold the cylinders to the frames of a locoomtive would stick when ti became necessary to remove them for repairs. The location is such that they cannot be struck with a wedge or hammer and a bar held against them, to be struck at the other end, was unsatisfactory and frequently useless. So a short mortar was made from a piece of an old axle, and fitted with a blunt-ended plunger or shot. The mortar was loaded with a charge of gunpowder and the shot slipped in and then the back of this miniature cannon was braced against the cylinder casting. When the explosion took place the shot was projected against the refractory bolt and the blow was usually so severe that the bolt was started, and what might have taken hours to accomplish was done is as many minutes.

Saw Dust Rollers

A man was handling or attempting to handle, alone, a heavy stick of timber on a saw table. It was hard work and the thing was troublesome. Stooping down he picked up a handful of sawdust which he scattered beneath the stick. He had put an innumerable quantity of little rollers under his weight and it moved with the ease of an inch board.

Punch for Sheets

Here is a description of a handy contrivance for punching, boiler, tank and other sheets, that is so inexpensive that any shop can afford to have one.

A track of light rails is laid upon the floor in front of the punch, and on them a carriage is made to travel where height is such that a sheet placed upon it, is at the proper level for punching. Bolted to the floor is a rack having teeth with a pitch equal to the spacing of the rivet holes. On the carriage there is a dog that drops into and engages with the teeth of the rack. One man pushes the carriage ahead, one notch at a time, and then draws it back until the dog has a solid bearing against the tooth of the rack, after each stroke of the punch. Another man stands ready to stop the punch should the first man fail to get the carriage in adjustment before the punch descends on the next stroke. With this arrangement a sheet can be punched as rapidly as the punch will work, and each hole will be properly spaced and in alinement, and that, too, without any laying out except for the first hole.

For changing the pitch of the rivets it is only necessary to change the rack beneath for each sheet is adjusted for a line of holes as soon as it is clamped in position for the first hole. There is no necessity for a gang of men to be kept busy at the punch. Two can do the work in about one-third the time consumed, in the ordinary way by a gang of four or five. Of course, it is essential that the wheels and rails be true and that the dog and rack shall be carefully machined, but, other than this, the apparatus requires no special care in its manufacture.

Bins for Small Articles

The ordinary bin for the storage of nuts, washers or pipe fittings is usually cheap, not very convenient and never cleaned. A great improvement in the ordinary form can be effected by making the front so that it will slide up and down, and be removable instead of being solid. This will make it possible for all of the contents to be easily raked out into a bucket or keg for stock taking and will probably also result in the shelves being occasionally cleaned.

A Novel Valve Stem Packing

This packing was once used but has never received an extensive application, nor is it especially recommended. It was applied to a locomotive, and while it was a trifle expensive, at the start, it was said to "fill the bill" with great success.

There was no gland and no packing like that in common use; but, instead, there was a cylinder about 4 in. in diameter and somewhat longer than the travel of the valve. This in place of the usual packing box. Then, on the valve stem, there was a piston head with three packing rings sprung into grooves. These made the joint.

The recommendations for the device were that it had run for more than three years without showing any apparent wear, and that the joint did not leak.

Straightening Blueprints

Everyone who handles drawings knows of the stubbornness with which a blue-print, that has once been rolled, will strive to remain in that condition. Rolling in the opposite direction is of little use as a straightener, but the most refractory blueprint can be made to lie flat. Take it to a drawing board or table, and allow the end to drop down over the edge, then by using the left hand to press it firmly against the table, draw the whole sheet down over the edge with the right hand, so that it will be bent back in a contrary direction to that in which it has a tendency to roll. One application is usually sufficient, but, if this fails, a second trial will usually complete the cure.

This will not, however, take out those fine wrinkles and creases that are often so great an annoyance when a blueprint is to be traced. To remove these the print should be thoroughly moistened and then gone over with a hot sad iron. This will remove the worst of creases and leave the print as smooth and flat as when it came from its own frame and bath.

Snap Shots by the Wanderer

I was asked a question the other day that was more than half suggestion in its implication that the methods of the civil service might well be applied to the selection of men for such a position as the traveling engineer or road foreman of engines. There was included also the implication that the men now holding these positions are not always as competent as might be desired. That they do not read or study and try to keep themselves posted and up-to-date so that why not use the civil service method of examination and do away with the suspicion of favoritism in the making of such appointments?

I do not know whether it holds now or not, but years ago there was a system of education in vogue in China according to which students shut themselves away from their fellows and devoted their time to the committing of the aphorisms and philosophy of Confucius to memory. Then, when their work was done, and they had been admitted to, let us say, the civil service, their advancement was said to depend upon their ability to apply these aphorisms to the affairs of everyday life. But anyone who has ever listened to the sing-song intonation of a Chinese boy for hour after hour, while committing Confucius, cannot be impressed by it as an effective means of mental development.

So our own civil service examinations and the training that prepares the candidate for them do not so much as imply any real mental training in that it teaches the man to think. It takes his brain and pours information into it, just as brains were poured into the skull of the scarecrow in the Wizard of Oz. Whether this information is retained or not will depend on the memory just as the retention of the brains by the scarecrow depended upon the leakage of the skull.

Our own civil service examinations were the outcome of blatant political abuse. Men and women of no ability and no training were appointed to positions which they were utterly incapable of filling, to the scandal of the service and the detriment of the exchequer. The examinations have at least insured that the candidates for an appointment shall have some preliminary training, but they have been far from insuring that the successful candidate shall be possessed of the ability or be capable of doing any independent thinking. In fact, the ability to think and act independently is not one of the requisites of a satisfactory departmetal clerk, as he is usually a person having no authority to act independently even if he were able to think. But the moment you place a man in authority he must be able to think and act for himself, and that is just the position in which a traveling engineer or road foreman of engines finds himself.

It used to be an old saying among the students of my day that the graduating senior could not pass the entrance freshman examinations. It is probably equally true that the experienced and capable superintendent of motive power would have great difficulty in passing the examinations by which he received his degree twenty years before. He learned many things in school that were pure theory that he had to apply to practice, but because he could pass a better examination at twenty-two than he could at forty-two did not mean that, at twenty-two, when devoid of experience, he was trusted with the responsibilities of a great mechanical department, which, at forty-two, with twenty years of application of his theories behind him, he administers with so much ability.

In short, men are not entrusted with responsibility merely upon their ability to give a glib answer to a compilation of questions. That they should be able to answer the questions, of course. But there should be something else, and promotion and the assumption of responsibility depends on something more than a parrot memory.

We give a candidate an examination, and then years of service on the left hand side before he takes charge on the right hand side of the locomotive.

So, coming back to the previous question, it is quite conceivable that a man might be totally incapable of passing an examination on the locomotive who might make a first-class runner and fine road foreman of engines, because of his clear intuition to do the right thing at the right time.

An old physician once told me that when he graduated from the medical school he knew exactly what to do for a typical case of typhoid fever, but the trouble was that, in all of his long experience, he had never had a typical case, but always one that had been complicated by other disorders, and he had been obliged to use his own originality and initiative in order to effect a cure.

Or take my own case for a further example. I am fairly familiar with the air brake. I think that I could pass a fairly good examination as to how a long train should be handled with it. But I am positively certain that if I were to attempt to make a stop with a 100-car train there would be so many variables popping up to harass me that, while I would be sure to make the stop, the train would be a wreck.

So the road foreman of engines never finds his typical case, and always has a multitude of variables to contend with that must be met, not only by a quick application of his theories, but by a still quicker application of his experience.

No, I would hardly recommend the appointment of a road foreman of engines on the basis of an ability to answer questions alone, any more than I think it advisable to give out the most important engine runs on the basis of seniority. You may and probably would get a

good man, but the chances are decidedly against your getting the best man available.

Apropos of the above. In the days when the advocates of the compound locomotive were loudly proclaiming its efficiency a certain example of that construction had been ordered for trial and had been declared a failure. It was of no use. So the builders sent a man to investigate and locate the trouble.

For the moral effect, and to avoid making the men who had been running the machine appear incompetent, he made a few perfunctory changes and then went out on a run.

For a time all went well, but when a heavy adverse grade was encountered the speed gradually fell off and the engine stalled.

"There, you see she's no good," said the engineer.

"Will you let me run her?" asked the visitor.

Then without doing anything more than changing the position of the reverse lever he made the locomotive climb the grade and topped it with a full steam pressure.

It was not a question then of passing examinations, but merely of the application of knowledge at hand.

To change the subject. I read a complaint the other day to the effect that much interchangeable machine work doesn't interchange, to which I can add a hearty "Amen." But sometimes it does interchange with a rush that takes one's breath away. For example, a number of years ago there was a certain manufacturer of steam engines doing business in New England who rather prided himself on the interchangeability of his wares.

He once received a telegram from a St. Louis (Mo.) flour mill ordering a new cylinder for one of his engines, the old one having been split, and asking as to when he could make a shipment. The answer went back: "Have one on hand. Shall we ship express or freight?" A quick reply said: "Express."

The first message came in the morning and before three in the afternoon the cylinder was on the way. In a week from the date of the breakdown the engine was again at work and not so much as a file mark had to be made in order to get the new work adjusted. The express bill was several hundred dollars, but I leave my readers to calculate as to how much would have been lost had the job been done in the ordinary manner. I merely wish to add that that New England manufacturer thereafter stood very high in the estimation of that flour firm in St. Louis. That was years ago, but from what I have seen and heard I am rather inclined to think that such an example of interchangeability would not be so much of a rarity today as it was then, for the use of jigs has had a wondrous growth in the past twenty-five years.

I am, if you will believe me, far too modest to think that my vaporings have much effect, for, like many other reformers, I have been as one crying in the wilderness, to whom no man listeneth. Perhaps some of my indulgent readers may recollect that one of my favorite topics is the parcel rack or what goes for that convenience in the day coach. I believe I have even scornfully said that about as well no rack at all as the diminutive receptacle for a lady's reticule to which we are so often treated.

Well, if not my words at least the sentiment has been adopted on some cars used, let us hope, solely on local trains whose passengers are not supposed to carry much, of any, hand baggage.

It is probable that the companies operating street, elevated and subway lines receive a substantial revenue from the advertising cards that are strung along the curve of the roof just above the windows. It will be noticed, too, that none of these cars have any semblance of a parcel or even of a reticule rack. But as they never did have, the space has always been clear for advertising cards.

But the steam lines have stood on their dignity and their cars have been free from the disfiguration or ornamentation of such cards. Use whichever designation that you please.

Now at least one road realizing that their Lilliputian parcel racks were of no earthly use to the public and that the space which they occupied had revenue producing capabilities, have adopted the sentiment of my preaching and have consigned the so-called racks their proper limbo and have put in their place the gorgeous promoters of cures of all ills to which the flesh of man and beast is heir, as well as the proper sustenance and clothing for that same flesh. All of which is as it should be, for the public has lost nothing by the change and, let us hope again, the company has gained amazingly in revenue if not in dignity and the refinement of the interior of their vehicles.

Equipment Utilized Most Efficiently

Strict adherence to the rules of the Car Service Division of the American Railway Association has enabled the railroads to utilize their equipment far more efficiently than ever before. In analyzing the equipment situation throughout the country, the Car Service Division says in a report recently issued:

"During the year 1925, there was maintained on Western roads at all times a supply of box cars equal to requirements and averaging above 95 per cent of ownership. This favorable condition was largely the result of a continuous flow of empty box cars of Western ownership to home territory from the East and South. Through Chicago and St. Louis alone this movement averaged 755 empty Western box cars per day for the entire year. A continuance of this movement currently is essential to a well balanced car supply in the West. This is being accomplished by constant supervision by the railroads and Car Service Division forces.

"There is an ample supply of refrigerator cars over the entire country at the present time. The Florida production shows a decrease as compared with last year and there is no problem of car supply involved in that territory so far as the perishable movement is concerned.

"The supply of open top cars for coal and other loading requiring the use of such cars is, and has been, generally adequate for all purposes and no shortages have occurred except in isolated instances and in those particular instances the shortages were relieved promptly through the co-operation of other railroads.

"That a real shortage of open top cars for coal and other loading did not develop during the latter portion of the year 1925 and the first six weeks of the current year is all the more remarkable when consideration is given to the fact that the bituminous coal production during the last three months of 1925 totaled 156,799,000 tons which was only 2,312,000 tons or 1.5 per cent under the previous high record for a similar period established in 1920.

"It is of interest to note that during 1920 the shortage of open top cars for the period October to December inclusive ranged from 2,159 to 27,549 cars per day and during the same period the surplus cars in reserve by the railroads ranged from a minimum of 107 cars to a maximum of 17,067 cars.

"In 1925 the maximum coal car shortage was 434 cars per day and the surplus cars in reserve by the railroads ranged from a minimum of 37,000 to a maximum of 95,000 cars.

"The bituminous coal produced during the first six weeks of the current year totalled 75,269,000 tons, an average of 12,545,000 tons per week, which is the highest production on record over a similar period."

Railroad Labor Board Abolished

President Coolidge signed the Watson-Parker bill which abolishes the Railroad Labor Board and sets up new legislation for the adjustment of railroad labor disputes. The bill creates a Federal board of mediation of five members to be appointed by the president which would function only after voluntary boards of adjustment for first negotiations had failed. Should the board of mediation fail to bring about a settlement of disputes over wages and a strike threatened, the president would be authorized to appoint an emergency board to investigate the whole dispute and make public the facts. No change in the transportation situation could be made by either side until thirty days after the board had reported.

Notes on Domestic Railroads

Locomotives

The Illinois Central Railroad has ordered 20 Mountain type locomotives from the American Locomotive Company.

The Red River Lumber Company has ordered 100-ton oil electric locomotive from the Ingersoll Rand Company, the American Locomotive Company and the General Electric Company.

The Union Pacific Railroad has ordered 14, 4-12-2 type three-cylinder locomotives from the American Locomotive Company.

The Illinois Central Railroad is inquiring for 50, 2-8-4 type locomotives.

The Essex Terminal has ordered one six-wheel switching locomotive from the American Locomotive Company.

The Union Terminal is inquiring for one six-wheel switching type locomotive.

The Northern Pacific Railway has ordered 12 Mountain type locomotives from the American Locomotive Company.

The Louisville & Nashville Railroad is inquiring for 32 locomotives.

The Southern Pacific Company has ordered one snow plow from the American Locomotive Company.

The Detroit & Toledo Shore Line Railroad is inquiring for 3 Mikados and 3 switcher type locomotives.

The Chicago West Pullman & Southern Railroad has ordered one six-wheel switching locomotive from the Baldwin Locomotive Works.

The South African Railways and Harbor Commission has ordered 23 Mountain type locomotives from the American Locomotive Company.

Freight Cars

The Baltimore & Ohio Railroad has ordered 1,000 car bodies from the Bethlehem Steel Company.

The Anglo Mexican Petroleum Company has ordered 5 tank cars from the General American Tank Car Company.

The International Railways of Central America has ordered 250 cars from the Gregg Car Company.

The Central Railroad of New Jersey has withdrawn its inquiry for 1,000 freight cars and has reentered the market for 800 box and 200 automobile cars all 50 tons capacity.

The American Steel Wire Company, Pittsburgh, Pa., has ordered 11 side dump cars from the Clark Car Company.

The Weatherford Mineral Wells & Northwestern Railway has ordered 300, 50-ton automobile cars from the American Car & Foundry Company.

The Cushing Refining Company, Tulsa, Okla., is inquiring for 10 insulated 8,000 gallon tank cars.

The National Railways of Mexico are considering the purchase of 6,000 freight cars.

The Tennessee Central Railway is inquiring for 100, 55-ton steel hoppers and 100 gondola cars.

The Delaware & Hudson Company is inquiring for 300 composite hopper cars.

The Fruit Growers Express has asked for bids on 1,200 steel underframes.

The Andes Copper Mining Company has ordered 26 tank cars from the American Car & Foundry Company.

The Union Oil Company has ordered 25 tank cars from the General American Tank Car Company.

The Illinois Central Railroad has ordered 4 air dump cars from the Differential Steel Car Company.

The Chicago and Northwestern Railroad is inquiring for 1,500 stock car bodies, and also for 25 caboose car underframes.

The Chicago, Rock Island & Pacific Railway is asking for bids for rebuilding 188 gondola cars.

The Pere Marquette Railway is inquiring for 30 hopper cars.

The Atlantic Coast Line Railway is inquiring for 50 caboose cars.

The Pittsburgh Terminal Coal Company is inquiring for 800 mine cars.

The Pere Marquette Railway is inquiring for 30 hopper cars.

The Atlantic Coast Line Railroad is inquiring for bids on 50 caboose cars.

The Boston & Maine Railroad has placed an additional order for 2 extension side dump cars with the Clark Car Company.

The South Porto Rico Sugar Company has ordered 80 cane cars of 30 tons capacity from the Magor Car Corporation.

The Youngstown Sheet & Tube Company is inquiring for one special rolling mill railroad car of 120 tons capacity.

Passenger Cars

The Southern Pacific Company is inquiring for 11 dining cars.

The Great Northern Railway is inquiring for 10 underframes for baggage cars.

The Seaboard Air Line Railway is inquiring for 10 steel diners.

The Illinois Central Railroad is converting 45 passenger cars for electric service.

The Chicago Surface Lines has ordered 100 Multiple Unit car bodies as follows: 33 from the J. G. Brill Company, 33 from the St. Louis Car Company and 34 from the Cummings Car & Coach Company.

The Louisville & Nashville Railroad is inquiring for 12 baggage cars and 15 combination mail and baggage cars.

The East Broad Top Railroad & Coal Company has ordered one passenger baggage gas electric motor car from the J. G. Brill Company, Philadelphia, Pa.

The Central Vermont Railroad has ordered one passenger baggage trailer from the J. G. Brill Company, Philadelphia, Pa.

The International Railways of Central America have ordered 2 chair cars from the Wasson Manufacturing Company.

The Reading Company has placed an order for 25 steel coaches and 5 passenger baggage cars with the Bethlehem Shipbuilding Corporation.

The Seaboard Ail Line Railway is inquiring for 15 steel coaches.

The Rutland Transportation Company, a subsidiary of Rutland Railroad, has ordered 3 automobile buses.

The Gulf, Mobile & Northern Railroad is inquiring for 2 combanation mail and baggage cars.

The Delaware, Lackawanna & Western Railroad is inquiring for 2, 60 ft. steel combination mail and baggage cars.

The Reading Company is inquiring for 4 cafe cars.

Buildings and Structures

The Chicago & Eastern Railway plans the construction of a new locomotive terminal to include an engine house, machine shop, coaling plant, etc., at Evansville, Ind.

The Atlantic Coast Line Railroad has awarded a contract for erection of shops and buildings at Tampa, Fla., to cost approximately $2,000,000.

The Illinois Central Railroad has prepared a contract for erection of shops and buildings at Tampa, Fla., to cost approximately $2,000,000.

The Illinois Central Railroad has prepared plans for the erection of a passenger station at Dyersburg, Tenn., next fall to cost approximately $140,000.

The Chicago, Rock Island & Pacific Railway has awarded a contract to T. S. Leake Construction Company, Chicago, Ill., for the construction of a 20-stall roundhouse at Burr Oak, Ill.

The Wabash Railway has awarded a contract to the T. S. Leake Construction Company, Chicago, Ill., for the construction of oil house at Moberly, Mo.

The Southern Illinois & Kentucky Railroad has awarded a contract to the Railroad Water & Coaling Handling Company for the construction of a reinforced concrete coaling station of 500 tons capacity at East Blufford, Ill.

The Southern Pacific Railroad has appropriated $450,000 for the construction of a roundhouse, car repair shed, office building and track facilities at Eugene, Ore.

The Richmond Fredericksburg & Potomac Railroad has authorized the extension of the Potomac transfer facilities including additional trackage facilities and an island platform at Potomac

Yard, Va., to cost approximately $48,000. The work will be done by company forces.

The Chicago Burlington & Quincy Railroad has placed a contract with the Roberts & Schaefer Company, for the immediate construction of a 175 ton capacity two track reinforced concrete simplex roller skip automatic electric locomotive coaling plant and a standard "N. & W." type electric cinder plant, at Daytons Bluff, Minn.

The Atlantic Coast Line Railroad has awarded a contract for the design and construction of a locomotive repair shop at Uceta, Fla., to cost approximately $1,000,000.

The Central of Georgia Railway is asking for bids on an eighteen stall addition to its enginehouse at Savannah, Ga.

The Gulf, Colorado & Santa Fe Railway has placed a contract for improvements to its Cleburne Shops at Cleburne, Texas.

The Yazoo & Mississippi Valley Railroad is having preliminary plans prepared for extensive yard improvements and additional shops at Vicksburg, Miss.

The Norfolk & Western Railway has placed a contract for an extension to its shops at Portsmouth, Ohio.

The Florida East Coast Line Railway will lay 50,000 feet of additional trackage at Fort Pierce, Fla. A southbound yard with a capacity of 325 cars will be constructed this summer, and a switching and breaking up yard with a capacity of 150 cars will be built.

The Atchison Topeka & Santa Fe Railway is planning to begin a $3,000,000 improvement project at San Diego, Calif., by building new yards and repair shops on its 120 acres adjoining Dutch Flats, at San Diego, Calif.

The Baltimore & Ohio Railroad and the Reading Company have awarded a contract for the first unit of a produce terminal at Philadelphia, Pa., to cost approximately $4,000,000. The new facilities will include driveway, platforms, tracks, loading and unloading equipment, and a refrigeration plant.

The Pennsylvania Railroad has awarded a contract to the T. J. Foley Construction Company, Pittsburgh, Pa., for the construction of additional yard facilities at Massillon, Ohio, to cost approximately $200,000.

The Chicago & Eastern Illinois Railway will be asking for bids within a short while for the construction of an engine terminal at Evansville, Ind., including a roundhouse and shop buildings.

Items of Personal Interest

G. E. Johnson, master mechanic on the Chicago, Burlington & Quincy Railroad, with headquarters at Sheridan, Wyo., has been transferred to Wymore, Nebr., succeeding **H. C. Cugler,** who has been transferred.

F. H. Becherer has been appointed superintendent of the car department of the Central Railroad of New Jersey, with headquarters at Jersey City, New Jersey.

Edward F. Smith has been appointed road foreman of Engines, Yellowstone division of the Northern Pacific Railway, with headquarters at Forsyth, Mont.

I. C. Blodgett has been appointed assistant to the mechanical superintendent of the Boston & Maine Railroad, with headquarters at Boston, Mass.

C. L. Beals has been appointed assistant general manager of the Florida East Coast Railway, with the same headquarters.

George I. Hayward has been appointed district engineer of the Northern Pacific Railway, with headquarters at Spokane, Wash.

Frank S. Robbins, formerly Philadelphia representative of the Pittsburgh Testing Laboratories, has been appointed superintendent of motive power and machinery of the Florida East Coast Railway, with headquarters at St. Augustine, Fla.

W. H. Fowler has been appointed general car foreman of the Southern Pacific Lines in Texas and Louisiana, with headquarters at Houston, Texas, succeeding **J. D. Freeman,** who has retired.

F. W. Gratiot, road foreman of engines of the Eastern division of the Missouri Pacific Railroad, with headquarters at Jefferson City, Mo., has been transferred to the White River division, with headquarters at Aurora, Mo. **F. W. Foltz** has been appointed road foreman of engines of the eastern division, succeeding Mr. Gratiot.

Thomas Owens, superintendent of the Duluth & Iron Range Railroad, with headquarters at Two Harbors, Minn., has been elected vice-president and superintendent, with the same headquarters.

George Seely, assistant chief draftsman of the Keyser Valley shops of the Delaware, Lackawanna & Western Railroad, with headquarters at Scranton, Pa., has been appointed assistant master car builder, with headquarters at Hoboken, New Jersey.

F. M. Sloane has been appointed district engineer of the middle district, Chicago, Milwaukee & St. Paul Railway, with headquarters at Milwaukee, Wis., to succeed **C. U. Smith,** who has resigned.

C. G. Chadwick has been appointed assistant to the vice-president of the Midland Continental Railroad, with headquarters at Akron, Ohio.

Horace Johnson, vice-president of the Duluth & Iron Range Railroad, has been elected president and general manager, to succeed **Francis E. House,** deceased.

William H. Williams has been elected chairman of the board of directors of the Denver & Rio Grande Western Railroad, to succeed **Alvin W. Krech.**

C. L. Bushnell has been appointed superintendent of transportation of the Kansas, Oklahoma & Gulf Railway, with headquarters in the Railway Exchange Building, Chicago, Ill.

J. P. Frian has been elected vice-president and general manager of the Fernwood, Columbia & Gulf Railroad, to succeed **Nedham E. Ball,** deceased.

W. S. Hobbs has been elected general manager of the Warren & Ouachita Valley Railway, with headquarters at Warren, Ark. **O. O. Axley** has been elected treasurer, with headquarters at Warren, Ark.

Supply Trade Notes

Roscoe Seybold, formerly manager of price statistics of the **Westinghouse Electric and Manufacturing Company,** has been appointed assistant to **F. A. Merrick,** vice-president and general manager of the company.

Mr. Seybold has been with the Westinghouse Company since 1907. He was born in Rockville, Indiana, and attended Purdue University. After graduating from that school in 1907, with the degree of Bachelor of Science in electrical engineering, he immediately came to East Pittsburgh, where he entered the college graduate apprentice course. At its completion, he was placed in the price department and later was transferred to the sales department, where he was located for some years prior to this present appointment.

George Sealy has been made chairman of the board of directors of the **International Creosoting & Construction Company,** to succeed **John Sealy,** deceased. **R. J. Calder** continues as president of the company. **J. D. Latimer,** manager of the tie and timber department has been promoted to vice-president and general manager. **H. A. West,** secretary and treasurer, has been promoted to vice-president.

Francis Hodgkinson, for many years chief engineer of the South Philadelphia Works, **Westinghouse Electric and Manufacturing Company,** was appointed Consulting Mechanical Engineer for the organization as a whole, taking effect immediately.

An official announcement to this effect was issued here and signed jointly by **H. T. Herr,** vice-president in charge of the South Philadelphia Works, and **W. S. Rugg,** vice-president in charge of engineering.

Simultaneously an order discontinuing the position of chief engineer of the South Philadelphia Works and creating instead the position of manager of engineering was announced. Appointed to the new position is **A. D. Hunt,** well known in engineering circles throughout the country and for many years a member of the engineering staffs of the Westinghouse organization.

With the duties and responsibilities of Mr. Hodgkinson broadened according to the new arrangement, his great knowledge, which has earned fame for him both in this country and abroad, will be made available to all of the operations of the company. His prime duty will be to act as consulting engineer in all design problems and other engineering activities at South Philadelphia.

In addition, however, he will contribute his effort in a consulting capacity on any mechanical problems arising under the necessities of the company at any other location. Likewise Mr. Hodgkinson, when required, will assist the sales department in the presentation of engineering subjects and will also be available in the same capacity to the Westinghouse Electric International Company, continuously engaged in engineering problems in many different foreign countries.

In April, 1925, Mr. Hodgkinson was the recipient of the Elliott Cresson Gold Medal, presented to him particularly in recognition of his important part in the development of the steam turbine, during more than three decades past. Mr. Hodgkinson, who was born in England, was educated at the Royal Naval School at New Cross, London, from where he graduated in 1882. Immediately after he served his apprenticeship and eventually went abroad in 1890, joining the Chilean Navy as an engineer officer. Upon leaving the navy, Mr. Hodgkinson became engineer for the Telephone Company and Electric Light Company at Lima, Peru, where he remained until 1892. Afterward he joined a mining company

operating properties at Casapalca in Peru, where he had charge of maintenance.

After his return to England, Mr. Hodgkinson rejoined **C. A. Parsons & Co.**, the famous turbine designers and builders, and when, in 1896, The Westinghouse Machine Company acquired the American rights for the manufacture of the Parsons type turbines, Mr. Hodgkinson, upon the recommendation of Sir Chas. Parsons, became connected with the Westinghouse Machine Company, which subsequently became the turbine building section of the Westinghouse Electric and Manufacturing Company.

Mr. Hodgkinson during the years following was gradually promoted and in 1916 was made chief engineer of the South Philadelphia Works, being advanced to his present position exactly ten years later.

Mr. A. D. Hunt, the new manager of engineering, has been connected with the Westinghouse Company for a number of years, occupying the position of manager of steam service at the South Philadelphia Works.

He was born in Tarrytown, New York, and received his school education in Connecticut and the State of New York. Eventually he entered Cornell University, from which he graduated in 1905 with the degree of mechanical engineer. Later the same year, Mr. Hunt joined **Westinghouse, Church, Kerr and Company**, in an engineering capacity, and eventually joined the Westinghouse Electric and Manufacturing Company, being assigned to the South Philadelphia Works, in September, 1919, in the Marine service section. He remained in that capacity until January 1, 1920, when he was appointed manager of steam service.

Robert Neal Piper, formerly sales representative of the **National Automatic Tool Company**, Richmond, Ind., has become associated with the **Cincinnati Shaper Company**, Cincinnati, Ohio, as a sales engineer.

On June first the Draft Gear activities of the **Westinghouse Air Brake Company** were assumed by the **Westinghouse Friction Draft Gear Company**, whose sales headquarters are at room 913, Peoples Gas Building, Chicago, Ill. This change has been made to more effectively serve the continually-increasing demand for the Type "X" Draft Gear. A full line of these gears has been developed to cover the wide range of service requirements. **Mr. H. B. Gardner**, formerly a representative of the Westinghouse Air Brake Company in the New York district, has been appointed general sales manager of the Draft Gear Company, with headquarters at Chicago.

Julian C. Smith has been elected to the board of the **Canadian General Electric Company, Limited.** Mr. Smith is vice-president of the **Dominion Engineering Works, Limited**; vice-president and general manager of the **Shawinigan Water & Power Company**, and a director of many other industrial and public utility organizations.

P. C. Fox has been appointed advertising manager of the **Niles Bement Pond Company**, to succeed **Donald M. Crossman**, who has resigned after sixteen years of service with the company.

John A. Black has been elected a director of the **American Steel Foundries**, Chicago, Ill., to succeed **Thomas Lynch.**

Fred H. Moyer, general superintendent of the **United Alloy Steel Corporation**, Canton, Ohio, has resigned to go into business as a consulting and development engineer.

H. B. Gardner has been appointed general sales manager of the **Westinghouse Friction Draft Gear Company**, with headquarters at room 913, Peoples Gas Building, Chicago, Ill. After graduating from Union College, Schenectady, New York, as a mechanical engineer in 1916, Mr. Gardner entered the employ of the Locomotive Stoker Company as mechanical expert, and later was advanced to sales representative in the Chicago district. In June, 1917, he enlisted in the 35th division of the 110th Engineers' Regiment, and was discharged in May, 1919, after having served twelve months as a non-commissioned officer in France. On his return he was made sales representative in the New York district. He left the employ of the Locomotive Stoker Company to enter the service of the Westinghouse Air Brake Company January 1, 1923, as representative; this position he was holding at the time of his new appointment, which became effective June 1, when the Draft Gear activities of the Westinghouse Air Brake Company were turned over to the Westinghouse Friction Draft Gear Company.

Angus D. Kohola has been elected treasurer of **E. I. duPont de Nemours & Company** to succeed **Walter S. Carpenter, Jr.**, who has become vice-president of the executive committee and vice-president in charge of finances.

Walter C. Doering, who has represented the **Bradford Corporation** at St. Louis, has been elected vice-president of the company, with headquarters at the Railway Exchange Building, Chicago, Ill., **William D. Otter** has been appointed manager of the western district, with headquarters in the Rialto Building, San Francisco, Calif., to succeed **W. W. Rosser**, who has resigned to engage in business for himself.

L. O. Stratton has been appointed district manager of the **Buda Company**, with headquarters in the Railway Exchange Building, St. Louis, Mo.

P. E. Floyd has been appointed manager of sales, in charge of the Chicago office and warehouse **Ludlum Steel Company**, Watervliet, New York, to succeed **H. W. Edwards**, who has been transferred to southern territory, with headquarters at Houston, Texas.

The Cleveland Pneumatic Tool Company has removed its Boston office from 60 High street to 142 Berkeley street.

F. B. Hamilton has resigned from the engineering department of the **Youngstown Sheet & Tube Company**, Youngstown, Ohio, to become assistant purchasing agent for the **Trumbull Steel Company**, Warren, Ohio.

Thomas O'Brien, service engineer and sales manager with the **John F. Allen Company**, New York, has left that company and become associated with the **Reliable Machine Tool Company**, New York City.

The Timken Detroit Axle Company has removed its office from 2 Rector street to 41 East 42nd street, New York City.

George W. Morrow has joined the sales staff of the **Ingersoll-Rand Company** and will follow the sales of compressed air equipment to the railroads throughout the middle western territory. Mr. Morrow succeeds **E. F. Kultcher**, who has been transferred to the locomotive department.

T. J. Pace, recently appointed director of sales, **Westinghouse Electric & Manufacturing Company**, has made the following appointments: Supervisor of development, **T. A. McDowell**; supervisor of costs, **W. C. Koehler**; supervisor of mixed apparatus negotiations, **C. F. Lloyd**; chief clerk, **M. H. Scott**; motor apparatus manager, **O. F. Stroman**; generating apparatus manager, **H. W. Smith**; traction apparatus manager, **A. J. Manson**; switch gear apparatus manager, **R. A. Neal**, and distribution apparatus manager, **G. S. Sawin.**

Herman Ely, who resigned as vice-president of the **Timken Roller Bearing Company**, Canton, Ohio, has been elected vice-president and treasurer of the **Servel Corporation**, New York.

R. E. Lounsbery has been appointed industrial sales engineer of the **S. F. Boweser & Company, Inc.**, with headquarters at Albany, New York.

A. E. Pratt has resigned as manager of the railway sales division of the **National Carbon Company** and the **Prest-O-Lite Company**, to take charge of the railway sales of **Duco** and other finishing materials for **E. I. duPont de Nemours Company**, with headquarters at Parlin, New Jersey.

The Chicago Steel Tank Company plans the erection of a plant which will be ready for occupancy in the fall at 6600 South Narragansett avenue, Chicago, Ill.

Obituary

Andrew Oswald Cunningham, chief engineer of the Wabash Railway died on May 11th at his home in University City, Mo. He was born July 8, 1866, at Rangoon, British Burmah, graduated from the University of Minnesota in 1894 with degree of B. C. E., entered railway service in 1886, since which he has been consecutively to 1888, rodman and leveler, Northern Pacific Railroad. Engaged in land surveying in North Dakota from 1890 to 1891; attended the university from 1891 to 1894, during which time he was also engaged in making maps of the city of Minneapolis, and making shop drawings for the Gillette Herzog Manufacturing Company of Minneapolis, Minn. He became draftsman for this company in 1894 and was their assistant engineer from 1895 to 1896. He was connected with the Schultz Bridge & Iron Company from 1898 to 1899, and with the Pennsylvania Engineering Company from 1899 to 1902, when he became bridge engineer for the Wabash Railroad in 1902 and became chief engineer September 1, 1905, for this road and its successor, the Wabash Railway, which position he held until 1922, when he became consulting engineer in river improvement work. He was retained as consulting engineer for the Terminal Railroad Association of St. Louis, and in 1925 was elected mayor of University City, Mo.

Harry Sneck, supervisor of air brake of the Buffalo, Rochester & Pittsburgh Railway, died May 16 after a brief illness. Mr. Sneck has been in the service of the Buffalo, Rochester & Pittsburgh Railway for over thirty-five years.

Charles J. Phillips, vice-president and general manager of the Brooklyn Eastern District Terminal, died May 4, aged sixty-five. Mr. Phillips was born at Morton, Ill., and attended Oskaloosa, College, Oskaloosa, Iowa, from 1878 to 1880. He entered railway service as a telegraph operator on the Wabash Railway in 1880, and later was made general agent at

Centerville, Iowa. He then entered the service of the Chicago Rock Island & Pacific Railway and served consecutively as general livestock agent, traveling freight agent, and division freight agent. He became superintendent of the Buffalo division, Delaware, Lackawanna & Western Railroad in 1900 and was made superintendent of the Morris and Essex division and New York City terminals of the same road in April, 1911, serving also as general manager of the Harlem Transfer Co. He was appointed general superintendent of the Delaware, Lackawanna & Western Railroad in 1917, and was made vice-president and general manager of the Brooklyn Eastern District Terminal at New York, in 1919, which post he occupied at the time of his death.

Morris Wuerpel, assistant to the president of the General Railway Signal Company, died on April 28 at his home in Rochester, New York, after a short illness. Mr. Wuerpel has been connected with the General Railway Signal Company since its incorporation and was in 1903 its resident manager at St. Louis. In 1905 he became manager of sales and installation at the home office, and in 1914 was promoted to the position which he occupied at the time of his death. Mr. Wuerpel was born at Little Rock, Ark., on October 31, 1870. Prior to his connection with the General Railway Signal Company he was superintendent of bridges and buildings of the terminal Railroad Association of St. Louis. Mr. Wuerpel, with his father, Morris Wuerpel, Sr., president of the Wuerpel Switch & Signal Company, St. Louis, designed and developed a power interlocking system which was exhibited at the World's Fair, Chicago, in 1903.

Thomas W. Crowley, former superintendent of the Adirondack division of the New York Central Railroad, and brother of Patrick E. Crowley, president of the road, died on May 18. Mr. Crowley began his career as an operator. He was made assistant superintendent of the Hudson division for a short while, going to Utica in 1913 as head of the Adirondack division. He was named superintendent in 1918 of the St. Lawrence division, with headquarters at Watertown, New York.

New Publications

Books, Bulletins, Catalogues, Etc.

The Articulated Car, The Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., has issued Leaflet 20,266, on "The Articulated Car of the B. M. T. Lines—Rapid Transit Division." This four-page leaflet, attractively presented in two colors, illustrates the important electrical equipment, includes the wiring diagram of the articulated car and in addition to a complete description of the motor, equipment and accessories, elaborates on the importance of this equipment as representing the latest development for rapid transit service. These new units comprise three complete subway-type bodies permanently coupled together and mounted on a total of four trucks using two Westinghouse motors each on the end trucks of the unit, together with double-end multiple unit control. This leaflet may be obtained from the Publicity Department at East Pittsburgh, or from any Westinghouse district office.

Electric locomotive Coaling Plant, The Roberts & Scharfer Co., Chicago, Ill., Bulletin No. 78, present several photo cuts of their automatic electric locomotive coaling plant of the simplex roller skip type, the bulletin also illustrates various designs of the circular reinforced concrete pockets used with this plant. This is the type of coaling station equipment which this company in its long experience has found to be the simplest and most substantial and dependable that can be offered to railroads. Forty highly successful installations of this type on leading railroads during the past four years also testify to its merits. This bulletin may be obtained by addressing the company.

Welding & Cutting Equipment. The Bastian-Blessing Company, Chicago, Illinois, are distributing their new Rego catalogue No. 40. This catalogue is the most complete one which the company have yet published and describes and illustrates the line of welding and cutting equipment furnished by them, including a large assortment of accessories.

The catalogue contains an excellent layout for a typical welding shop. It gives a plan view with dimensions and a front elevation. The general plan for cranes, drill presses, air compressors, grinders, etc., and the location of the welding tables, the oxygen manifold, generator room, sludge pit, etc., have been well thought out and the arrangement is excellent.

It also gives useful information concerning gases, useful conversion factors, flame temperatures, useful facts for welding, spark tests to determine different kinds of iron and steel, properties of metals, etc.

This catalogue may be obtained by addressing the company at 240 East Ontario street, Chicago, Ill.

Sheet Metal Welding by Acetylene Process. This book has been issued by the Linde Air Product Company of New York. This book has been compiled Mr. T. C. Fertherston of the publicity department of the Linde Air Product Company. It contains 259 pages, and covers practically every phase of sheet metal welding. There are photographs and diagrams. It is divided into such subjects as Patterns and Layout Methods, Preparation of Material and Assembly, Welding Non-Ferrous Metals and Alloys, Testing Welds, Shop Organization Cost Records and Cost Estimating, etc. It is by far the most complete treatise which has been published upon this subject. The book has been prepared in an effort to aid those who weld sheet metal. This may be obtained by addressing the company at 30 East 42nd street, New York, N. Y., or Railway Exchange Building, Chicago, Ill.

Railway and Locomotive Engineering

A Practical Journal of Motive Power, Rolling Stock and Appliances

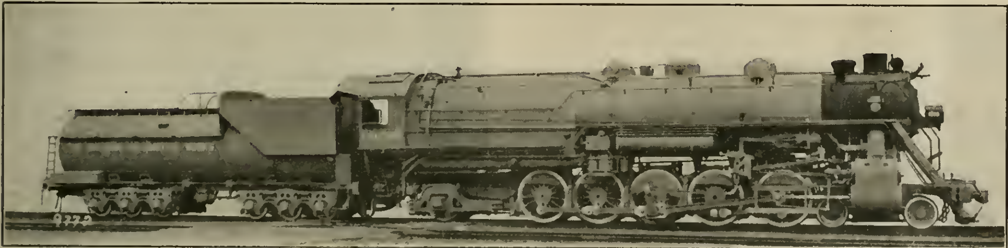
Vol. XXXIX 136 Liberty Street, New York, July, 1926 No. 7

New Design of Three-Cylinder Compound Locomotive

Baldwin Locomotive Works Displays 4-10-2 Type Equipped with Water Tube Firebox and Employing 350 lb. Steam Pressure

A highly interesting feature of the track exhibits at Atlantic City during the convention of the Mechanical Division of the American Railway Association last month was a three-cylinder compound 4-10-2 type locomotive exhibited by the Baldwin Locomotive Works and numbered as the 60000 locomotive turned out by the builders.

The recent trend in locomotive development has been in the adoption of the three-cylinder arrangement, and the use of higher boiler pressures. In this new design the Baldwin Locomotive Works have introduced the three-cylinder arrangement on a compound principle.



New Three-Cylinder Compound Locomotive Built by the Baldwin Locomotive Works

Locomotive designers and motive power officers are directing their attention to increased efficiency through the use of water tube fireboxes and higher steam pressure. In this new development a steam pressure of 350 lbs. is employed and a water tube firebox is provided. The firebox is somewhat similar to the Brotan design which was described in the January, 1923, issue of Railway and Locomotive Engineering. Water tube fireboxes are used on some European railways and the Brotan type has reached its highest development on the Hungarian State Railways, where locomotives so equipped have shown economy in fuel consumption of 8½ per cent as compared with locomotives equipped with ordinary fireboxes.

Locomotive No. 60000 has a firebox with a hollow cast steel mud ring and two horizontal upper drums, with water tubes which replace the side water legs used in a boiler of the ordinary type. The front end of the mud ring is connected to the boiler barrel by two circulating pipes. A 50-element superheater is installed, and the throttle valve is placed in the smokebox, while there is a shut-off valve in the dome at the rear end of the dry-pipe.

The cylinder casting is of iron, and is made in one piece. The inside cylinder is the high pressure, and its exhaust passes simultaneously into the two outside cylinders which are the low pressure. All three cylinders are of the same dimensions. The high pressure cylinder is connected to the second pair of driving wheels, and the two low pressure cylinders to the third pair. The outside cranks are placed 90 degrees apart, while the inside crank is at 135 degrees with each outside crank. With this arrangement there are four even exhaust per revolution when the engine is working. The locomotive is started by admitting high pressure steam direct to the outside cylinders through a manually controlled valve placed in the cab. Walschaerts valve gear is applied to all three cylinders.

With the introduction of such refinements in locomotive design, we can safely predict still higher efficiencies than now obtained in railway operation.

The tender is equipped with two 6-wheel trucks and has a tank capacity of 12,000 gallons and 16 tons of fuel.

The locomotive exerts a tractive force of 82,500 lbs.

The accessories are all operated by superheated steam at a reduced pressure of 250 pounds, except the feed water heater and injector, which use saturated steam at 350 pounds pressure.

This engine is equipped with superheater, feed-water heater, stoker, power reverse and air brake on all driving,

back truck and tender wheels with two 8½-inch cross compound pumps.

We hope to present some details of the performance record of the locomotive in a future issue of this paper and when tests have been completed.

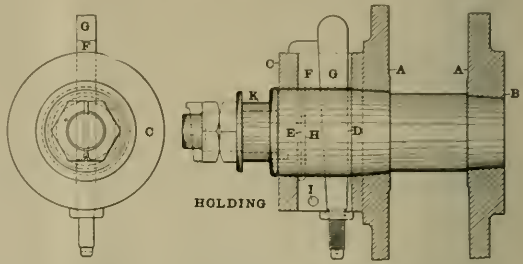
The principal weights and dimensions of the locomotive No. 60000 are given in the following table:

Three-Cylinder Compound 4-10-2 Locomotive

Cylinders	
High pressure (1)	27 x 32 ins.
Low pressure (2)	27 x 32 ins.
valve	Piston 14 ins. diam.
Boiler	
Type	Wagon Top.
Diameter	84 ins.
Working pressure	350 lb.
Fuel	Soft coal.
Firebox:	
Type	Water tube.
Length, total	199½ ins.
Width, total	96 ins.
Length of grate	138¼ ins.
Width of grate	86 ins.
Water tubes, number	100 ins.
Water tubes, diam.	4 ins.
Boiler tubes, diam.	5½ ins. and 2¼ ins.
Boiler tubes, number	5½ ins., 50; 2¼ ins., 206.
Boiler tubes, length	23 ft. 0 ins.
Water heating surface:	
Firebox	745 sq. ft.
Tubes	4,420 sq. ft.
Firebrick tubes	27 sq. ft.
Total	5,192 sq. ft.
Superheating surface	1,357 sq. ft.
Grate area	82.5 sq. ft.
Driving Wheels	
Diameter, outside	63½ ins.
Diameter center	56 ins.
Journals, main	12 x 13 ins.
Journals, other	11 x 13 ins.
Engine Truck Wheels	
Diameter, front	33 ins.
Journals	7 x 12 ins.
Diameter, back	45½ ins.
Journals	9 x 14 ins.
Wheel Base	
Driving	22 ft. 10 ins.
Total engine	45 ft. 2 ins.
Total engine and tender	86 ft. 11¼ ins.
Weight in Working Order	
On driving wheels	338,400 lb.
On truck, front	57,500 lb.
On truck, back	61,600 lb.
Total engine	457,500 lb.
Total engine and tender	700,900 lb.
Tender	
Wheels, number	Twelve.
Wheels, diam.	33 ins.
Journals	6 x 11 ins.
Tank capacity	12,000 gal.
Fuel capacity	16 tons.
Tractive force	82,500 lb.

The Becker Improved Wristpin

Mr. H. G. Becker, superintendent of shops of the Delaware & Hudson Company, has recently designed and patented a new form of wristpin that is an improvement over the type ordinarily used. This ordinary wristpin is put in place from the inside and is held by a nut upon the outside. It is exceedingly inconvenient to either put in position or remove, especially on locomotives having more than two pair of driving wheels, because of the necessity

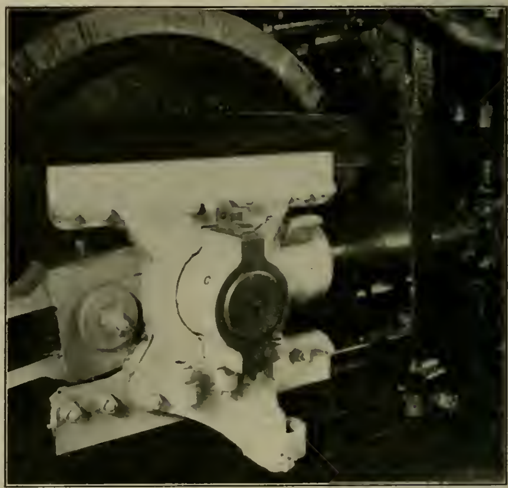


Details of Becker Wristpin in Holding Position

of so spotting the engine that the spokes of the driving wheels will not interfere with the setting of the pin.

The peculiarity of this new type of pin is that it is both put and held in place from the outside and that the holding is done by a readily removable key instead of a nut.

Referring to the illustration, the two sides of the cross-head *AA* are bored with holes having the large



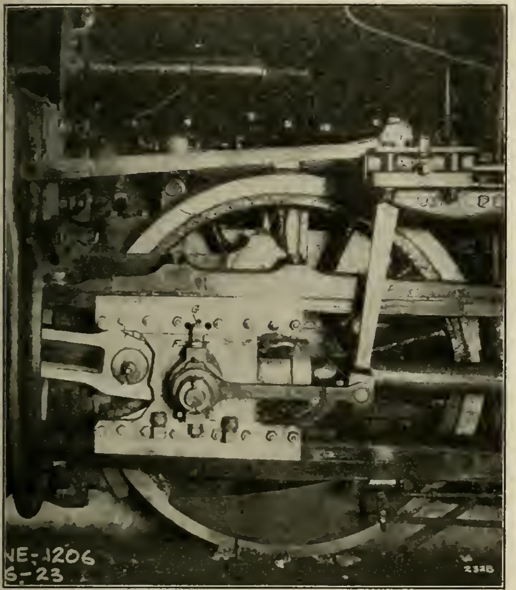
Becker Improved Locomotive Wristpin

diameter of the taper towards the outside, and it is into these holes that the pin is pushed from the outside, coming flush with the inside face of the crosshead at *B*.

The outside of the crosshead carries a hub or boss *C* through which a cylindrical extension of the pin projects. In the case of new crossheads this limb is made integral with the front plate; but, when the pin is being applied to an old crosshead the hub is welded on. That this can be efficiently done is shown by tests of the holding power of some of these welded hubs, which have carried a load of 100 tons without failure. The hub is slotted vertically

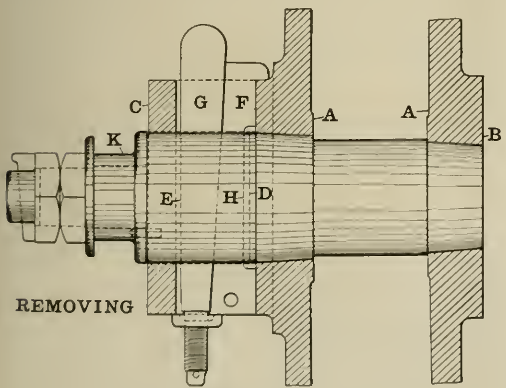
to admit the passage of a gib and key as shown by the illustration. The cylindrical projecting portion of the pin is also slotted to take the gib and key as indicated by the dotted lines *D* and *E*.

When the pin has been pushed into place the gib *F* is dropped through the slots of the hub and pin, and brought up against the outer face of the slot in the hub. It will



Becker Improved Locomotive Wristpin

be noticed that the gib is cut away on its straight face, as shown by the dotted line *H*, so that it clears the outside end of the slot in the pin at *E*. The key *G* is then dropped into place and driven home. As the key has a bearing against the inside end of the slot at *D* and the gib



Details of Becker Improved Wristpin

rests against the outside end of the slot in the hub, the pin will be crowded inwardly against the taper holes in the crosshead.

The gib is held in place by a pin in the hole *I* and the key by a nut on the threaded portion at the bottom.

That the wristpin is securely held in place by this arrangement has been thoroughly demonstrated in practice where a number of engines to which it has been applied have run between shoppings without loosening in the slightest. In one case, in order to test the device, an engine was sent out in which there was 1/16 in. play between the rod brasses and the pin. Yet, despite the terrific pounding to which it was subjected, there was no loosening.

With the pin forced into the tapered holes by the key it is wedged in place so solidly that considerable force is required in order to remove it. To drive it out by a bar from the inside would be very difficult. It is so arranged that it can be removed by the same gib and key that are used to hold it.

This is done by dropping the gib into the slot the other way around, so that its straight side bears against the inside end of the slot in the hub, and its cutaway portion *H* clears the inside end of the slot *D* in the pin; while the straight face of the key bears against the outside end of the pin slot at *E*, so that, when it is driven down, it will pull the pin out and loosen it. In this way a few seconds serves to remove the pin.

In the illustration the pin shown has an extension over which a bushing *K*, held by a dowel pin, is slipped to serve as a bearing for the crosshead end of the union bar of the Walschaerts valve gear. This is also held by the nuts and split pin as shown.

In cases where the union bar connects below the guides a plate having a hole large enough to slip over the hub on the crosshead is bolted to the outside face of the latter, as shown in the side elevation of the crosshead.

Pennsylvania Orders Seven Electric Locomotives

The American Brown Boveri Electric Corporation has received orders for the electric equipment of seven electric locomotives from the Pennsylvania Railroad. The mechanical parts of the locomotive will be built at the Pennsylvania shops in Altoona, Pa. The electrical equipment will be built at the Camden, N. J., plant of the Brown Boveri Corporation.

The locomotives will operate either from a 600 volt, direct current third rail, or from an 11,000 volt, alternating-current overhead trolley. They will be single cab locomotives similar in appearance to the L-5 type locomotives now in service in the New York terminal. By changing the gear ratio, the locomotives can be used for either passenger or freight service. The locomotives are designed to haul a 16-car passenger train at 75 miles an hour, or, as freight locomotives, to haul a tonnage train at 35 miles an hour. Each locomotive will have four driving motors, with a combined continuous rating of 3,640 hp. The driving wheels will be 80 in. in diameter and the load on each driving axle, 75,000 lb.

When these locomotives are placed in service, the motive power displaced will be transferred, it is understood, to the Long Island division of the Pennsylvania. Subsequently, the new locomotives are expected to be used on the main line electrification project of the Pennsylvania which is being initiated and is now under construction between Philadelphia, Pa., and Wilmington, Del., a distance of 28 miles. The new locomotives will be used individually or in multiples, according to the character of the trains to be handled.

The program of the Pennsylvania contemplates the ultimate electrification of all suburban lines in the Philadelphia district. It is expected to be completed in 1927. It is estimated that the total cost would be about $10,000,000 exclusive of the cars which will be required.

Electric Power and the Railroads

By A. H. Armstrong, Assistant Engineer, Railway Department, General Electric Company

Just what part in our future national economic development will be played by electricity is perhaps difficult to express in figures. That it is becoming a large factor is evidenced by the growth of the electric power industry from one billion to seven billions of invested capital in the short time of 20 years. Nearly half of all the industries have already been electrified and electric motors find a field of application even in coal and oil mining, where a foothold would seem economically improbable.

The large industry concerned in this article, however, has been electrified only to a comparatively small extent. As yet, on only two per cent of the road mileage in this country have steam engines been replaced by electric locomotives. Standing greatly in need of improved facilities and service to enable it to meet the growing demands of modern society and the increasing competition of gas-propelled vehicles operating on state highways, our rail transportation system is still operating under steam-engine haulage on 98 per cent of its lines.

A study of Fig. 1 indicates the interesting relation existing between the growth of the country's population and the revenue ton-miles hauled over the railroads. In the past 25 years the population has increased 50 per cent,

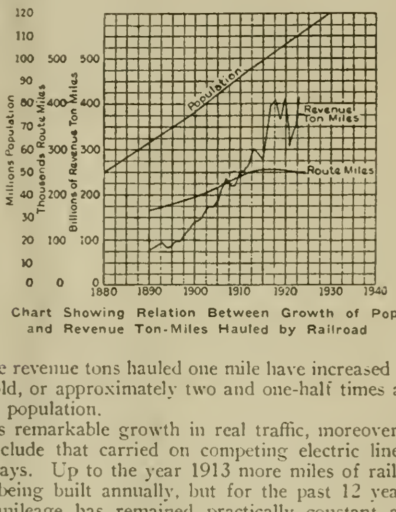


Fig. 1. Chart Showing Relation Between Growth of Population and Revenue Ton-Miles Hauled by Railroad

but the revenue tons hauled one mile have increased nearly fourfold, or approximately two and one-half times as fast as the population.

This remarkable growth in real traffic, moreover, does not include that carried on competing electric lines and highways. Up to the year 1913 more miles of rail route were being built annually, but for the past 12 years the road mileage has remained practically constant around 250,000 miles for all roads. This discloses the fact that the railroads of the United States have entered a new phase of their growth and, instead of building into new territories, are now engaged in intensively improving existing lines.

The fact that the railroads have ceased (temporarily at least) to be empire builders, given up the operation of coal mines, and turned to the better development of their legitimate field—transportation—opens up wide possibilities of improving a huge machine that is vulnerable in many points. The records of the 69,000 steam engines now in operation do not show a high efficiency as power producers, and the cost of their upkeep is much in excess of other types of motive power performing the same service. The demand for better service in and around large cities has led in many instances to the replacement of the steam engine by the electric multiple-unit train to the mutual advantage of the railroad and traveling public. The most powerful hauling machines ever built are electric locomotives, and their successful operation is a convincing demonstration of their fitness for the heaviest rail service. The electric motor is a most flexible source of power, both in construction and adaptation to any of our steam railways is the next big step in the betterment of the country's transportation lines.

Viewed from the standpoint of power-station development, the magnitude of the project of furnishing electric power to all railways in the country is less than the achievement of the industry in the past 20 years. Furthermore, no new and untried construction is involved. The art of electric power production is standardized and its economic and operating success assured.

Whether electric power for such a gigantic project shall be furnished from central power stations owned by utility companies or by the railroads, it is of interest to form some approximate idea of the magnitude and character of a national railway load. In one respect it is peculiar. While its volume compares favorably with the total electric power now generated, the prospective railway load is distributed over some 250,000 miles of route. The term "load-factor" applied to railway load must therefore embrace a reasonable mileage of track in order that it may approach that high percentage which meets with the favor of electric power producers. A single heavy freight train drawn by electric locomotives may demand as high as 10,000 kw. maximum on the ruling grade and yet average but a fraction of this amount of power over a 100-mile route of broken profile. On down grades, electric power may be delivered to the trolley, generated by the descending train. Considered as an individual load, one electric locoomtive may therefore present a very ragged load curve, dependent upon profile and traffic conditions. On the other hand, several such locomotives operating over a route, say 200 miles long, may in combination produce a resultant 24-hour load-factor at a single source of power that could easily approximate 70 per cent under favorable conditions.

Immediate appreciation must be given the fact that the railroad industry provides a day and night load of some uniformity during the 24 hours, outside the influence of daily train service near very large cities. As power stations supplying railroad loads will undoubtedly be interconnected, it is probable that such loads will be viewed in a broad spirit and reasonable lengths of track included in one contract agreement, if power is purchased, thus establishing a load-factor for 24 hours that may compare very favorably with that of other industries.

From records of electric train operation, it is possible to arrive at a relation between gross ton-miles moved and watt-hours consumed that may be accepted as reasonably accurate for the several classes of train movements. Such a relation is applied in Table I to the tonnage moved during the year 1923 on Class 1 roads, with a resulting estimate of electric power that would have moved the same traffic. Power is estimated at the trolley, as this is the point of utilization by the railroad and, if purchased, should be the point of delivery by the power company.

This estimated load of 33 billion kilowatthours is approximately 60 per cent of the electric power now being generated. In point of magnitude, the project of financing and building electric power stations to furnish power to all our railroads represents only two-thirds the accom-

plishment of the past two decades of power-station development for other industries. Considering that but half our industries are electrified, it is apparent that the total railroad load may amount to but little more than 25 per cent of the aggregate electric load possibilities of the country.

TABLE I—ESTIMATED ELECTRIC POWER FOR YEAR 1923
Class I Roads

Service	Millions of Gross Ton-miles	Watt-hr. Per Ton-mile at Trolley	Millions of Kw-hr.
Freight	1,085,765	20	21,700
Passenger	336,100	25	8,400
Switching	54,800	50	2,740
Total	1,476,665	Average 22.5	32,840

Combined locomotive and trolley efficiency 75 per cent.
Gross ton-miles includes engines and tenders.

This railroad power is estimated at the trolley on the supposition that the generation, transmission, and conversion of power to the kind desired by the railroad for locomotive propulsion is a separate industry, whether financed by railroad or private capital. Additions to capital strictly chargeable to the electrification of railroads, under this accounting, would be limited to trolley construction, electric locomotives, and incidentals.

The performance of steam engines in the production of train power is pertinent to this general statement. For convenience of comparison, the steam-engine power estimated to have hauled the freight and passenger traffic for the year 1923 is reduced in Table II to equivalent electric power at the trolley.

TABLE II—STEAM ENGINE PERFORMANCE FOR YEAR 1923
Class I Roads

Service	Millions of Gross Ton-miles	Million Kw-hr. Equiv. Elec. Pr. Trolley	Tons Coal Burned	Lb. Coal Per Kw-hr.	Cost of Steam-engine Power, Cents Per Kw-hr.
Freight	1,085,765	21,700	90.3	8.58	1.56
Passenger	336,100	8,400	31.6	7.52	1.37
Switching	54,800	2,740	24.1	17.60	3.02
Total	1,476,665	32,840	145.0	8.84	1.61

Several vital facts may be deduced from this tabulation.

(1) Steam-engine performance in Class 1 road service during 1923 produced approximately 33 billion horsepower-hours at the driver rims, equivalent to 33 billion kilowatt-hours electric power measured at the trolley, allowing for 75 per cent efficiency between drivers and trolley input.

(2) Coal burned per hp.-hr. at drivers averaged 8 lb. for road engines and over 17 lb. for switching.

(3) Cost of steam-engine coal for road service averaged 1.47c per hp.-hr. at drivers, or the same figure per kilowatt-hour for equivalent electric power, measured at the trolley, that would have hauled the same trains by electric locomotives.

(4) The estimated power demand by Class 1 railroads in 1923, approximating 33 billion kilowatt-hours at the trolley (or 41 billion kilowatt-hours at the power station), is 75 per cent of the 55 billion kilowatt-hours generated in 1925 for other electrified industries in this country.

There are several modifying comments necessary to a fuller understanding of the power estimates for railroad load given in this general statement.

(1) The gross ton-miles given include steam-engine tenders and idle guiding or trailing axles which together constitute nearly half the total engine and tender weight of road engines. A large part of this non-productive weight could be eliminated by the use of electric locomotives. As freight steam engines equal approximately 14 per cent and passenger steam engines 37 per cent of the gross trailing loads, the saving in electric locomotive ton-miles having little or no idle weight will effect a material reduction in the power estimates given here for steam-engine train movement.

(2) Non-revenue company coal and car movement constitutes an appreciable percentage of the total gross tons hauled and this will be eliminated in large part by electrification.

(3) Part of these savings will be offset by fuel required to heat electrically-hauled passenger trains.

(4) It is fully appreciated that the average figures of 1923 for all roads do not reflect the best performance of modern steam engines, and the fuel economy of the latter (where installed) is much higher than the average record of all engines of all vintages now operating.

Stupendous as the task is of financing and constructing electric power stations of sufficient aggregate capacity to electrify all the railroads in the United States, it is a smaller accomplishment than has already been achieved in furnishing power to other electrified industries during the past 20 years.

In the year 1923, road engines of Class 1 roads produced power at the drivers at a cost of approximately 1.5c per hp.-hr. and switch engines at 3c per hp.-hr. Both of these figures promise a reasonable return upon the average expenditures and operating costs of electric power houses delivering power to the trolleys of the electrified roads. While the fuel economy resulting from the substitution of electric for steam-engine power is apparently not sufficient in itself to justify the expense of steam road electrification, except in favored localities enjoying the advantage of cheap electric power, the subject of electric power for railroads is dwelt upon at length in this article to present certain fundamental facts pertinent to the situation and in particular to draw a picture showing the magnitude of the task confronting the railroads and power companies interested in replacing steam engines by electric locomotives.

The reasons influencing the adoption of electrification in many instances may be found among the following:

(1) Increase in locomotive power, making possible the haulage of heavier trains at higher speeds.

(2) Increased track capacity resulting from Item (1). Under favorable conditions it may cost less to electrify than to lay additional track in congested divisions.

(3) Improved operating conditions in general, longer engine runs, elimination of coal and water stops, greater reliability and freedom from delays due to steam-engine power as such, advantages of regenerative electric braking on heavy grade divisions with its openings, economic and safety features, multiple-unit trains, and improved terminal service, etc.

(4) Economies of operation resulting from greatly reduced locomotive maintenance, shop and round-house expenses, crew expense, elimination of coal, water, ash, and turntable facilities, heavier trains at higher speeds, reduction of relays, overtime, etc.

As a means of improving rail transportation the electric motor whether it is applied to different mountain grades or congested city terminals offers an operating and economic relief from the restrictions imposed by steam-engine power. With these fundamental facts demonstrated in a number of typical instances, the electric motor and central station power should play a most important part in the series work of future railway development.

Mechanical Division Meeting of the American Railway Association

Record Attendance and Exhibit Features Atlantic City Convention

The Mechanical Division of the American Railway Association which embraces the former American Railway Master Mechanics' Association and the Master Car Builders' Association held its annual meeting on the Million Dollar pier, Atlantic City, N. J., June 9-16. The chairman of the general committee for the meetings was J. T. Wallis, chief of motive power of the Pennsylvania System.

It was the largest of any meeting of the organization, both in point of attendance and in the extent of the exhibits.

The Railway Supply Manufacturers' Association provided a wonderful display of devices and equipment on the pier, while an extensive exhibit of machine tools was housed in a building opposite the pier. The track exhibits consisted of new designs of steam and electric locomotives, cars, etc. In a large tent automobile buses and trucks were displayed.

On June 9th the meeting was addressed by Dr. Samuel M. Vauclain, President of the Baldwin Locomotive Works, and R. H. Aishton, President of the American Railway Association. Both of these addresses as well as extracts from some of the committee reports appear elsewhere in these pages. The first business session was formally opened by an address by Chairman Wallis, which follows:

Address by Chairman Wallis

"About the time you were in session last year I was attending the meetings of that great association of railwaymen, the International Railway Congress in London. I do not intend to criticize the activities of that association because it would be impossible for me to make a constructive criticism. Men of many countries with different forms of government all speaking different languages have difficulty in agreeing on details as distinguished from fundamentals. As in the case of our parent body, the American Railway Association, the action of the body is not compulsory on its members.

"Later, when I traveled over England and France and saw the multiplicity of design of equipment like journal boxes, brasses, etc., when we have but one pattern, I realized the priceless thing the famous old Master Car Builders' Association did when it framed our interchange agreement, and made standardization in essential things compulsory. Our older members, like the framers of the Constitution of the United States either wrought better than they knew or were very wise, and it is my pleasure to think it was the latter.

"Gentlemen, there is no other place in the world where there are 2,500,000 freight cars, the largest freight cars in the world, owned by as many corporations as comprise the railways of this country, moving under one agreement which provides for essential standards and is substantially a contract enforceable in the courts. We owe that constructive piece of work to the M.C.B. Association.

"To our members who concern themselves chiefly with locomotives, and were members of the old Master Mechanics' Association, I want to tell what struck me most forcibly about their affairs. It was what we accomplish on account of the size and the way we handle our locomotives.

"The railway rates are higher in England than they are in this country. The total earnings of the four English systems are approximately 900 million dollars a year. It just so happens that the earnings of the Pennsylvania Railroad are about one-tenth of the earnings of all the railroads in this country, or approximately 700 million dollars. I believe the earnings of the Pennsylvania Railroad would be as high as 900 million dollars a year if our rates were as high as the rates in Engand. The Pennsylvania Railroad, which in this respect is not any better operated than any other carrier, earns this money with approximately 7,000 locomotives while there are about 24,000 on the English railways.

"The foregoing is not said in the spirit of criticism of English railways. I am not one of those who think English railways should adopt all our methods and use our equipment. I have seen enough to make me believe that is not possible, and at any rate I should not want to express a fixed opinion on that broad subject after only a flying visit. The statement I have made, however, is a fact and indicates in a rather spectacular way the energetic manner in which our locomotive designers and operators have met our long haul and tremendous traffic.

"Going back to the business for which we are meeting, the report of our secretary contained in the report of the board of directors of the American Railway Association, together with the program of this week, embodies in detail everything that the association has done within the year. The work has proceeded in a quiet orderly way and a great deal has been accomplished. It seems to me that there has been a greater willingness on the part of the members of the various committees to compromise their individual views in the interest of the railroads as a whole than ever before and, that we may expect much progressive work and accomplishment by reason of this fact.

"I think the foregoing is best exhibited by the work of the car construction committee. I do not believe that there is any association of railwaymen in the world representing half the miles represented by this association that either could or would have been willing to eliminate their personal views to the extent necessary to adopt a standard car in the interest of the body as a whole.

"In the year to come I hope that we will be able to settle in a more or less fundamental way what, if any, modification in the characteristics of brakes we should make as compared to those who are now recommending; that something fundamental will be developed in connection with draft gears which will eliminate at least a large portion of the doubt and discussion which has taken place on this subject throughout the country and, that we will extend your present rules in regard to the standardization of box cars to cover other cars.

"To the Railway Supply Manufacturers' Association I wish to say its members seem to have outdone themselves this year in the excellence and extent of their display. I wish to thank them in the name of the mechanical division for their great interest in this matter."

Address by R. H. Aishton, President of American Railway Association

"The pressure on the mechanical officers of the railways today has increased and will increase as the years go by. The demands for better and more adequate service,

and particularly for more economical operation, have not let up for a minute in the past six years, and for the comfort and encouragement of you men of the mechanical division, without attempting to stand in the role of a prophet, I think I can predict confidently that this pressure will continue, and that it will be accentuated in the many years that lie before you. The answer to it lies in the results that have been attained in the past few years, which may be epitomized in the term 'Public Relations.'

"You know what the relations were with the public in 1920. You know what the problem was that faced the railroads, and you know how much courage it took for the railway executives of this country, facing those conditions, to enter into a program of capital expenditures amounting to over four billion dollars in the past six years, for increasing their capacity and facilities to do what was necessary to provide adequate transportation. That the wisdom of their courageous action has been demonstrated in the fact that in the last three years at no time has any question arisen in this country as to the adequacy of the transportation.

"In other words, if a man had a car of hogs in Iowa, a car of cotton in Texas, a car of juice grapes in California, when he wanted a car, the car was there, and it was moved, and it was moved faster than it was ever moved in the history of the country before, to the greater satisfaction of the public. That has had a remarkable influence on public opinion regarding the railways.

"Furthermore, the ability of your mechanical officers to get more efficient operation out of what you had has contributed in no small measure towards the result of providing adequate transportation. It has had a marked effect also in the economies with which that transportation has been produced, until today the railroads are quoted by those in authority, and stand in the general estimation of the public, as being in the forefront of industry, not only as to the public service afforded, but also as to being alive to every method productive of efficiency and economy in transportation.

"Every time, when by discussion in some of your committees, or through a report or during the convention, you succeed in saving a pound of coal per thousand-ton miles in freight movement in this country, there is the point that counts. Every time you develop, through the cooperative work between yourselves and the supply people and the manufacturers, or through the members of your committees, a machine capable of moving a thousand tons of freight a little faster and a little cheaper than it ever was moved before, that is another point that counts.

"What is public relations work? As I see it, it's everything the railways say or do not say, do or do not do, that will affect public sentiment toward them. Keep that in mind. Have in mind better sentiment all the time in everything you do.

"What are the things that appeal to public opinion?

"First, the character of service the public gets. As I said before, this has been of such a nature that there is general public satisfaction.

"Second, that every possible economy be attempted in producing transportation.

"In both these lines your division has done and is doing a great work. Take the matter of standardization of box car design. Due to refinements in design, these cars are of considerably lighter weight than many 80,000 pound capacity cars designed and built a few years ago, including the United States railroad administration design. They are as much as 3,000 pounds lighter than the 80,000 pound cars built by some railroads five and six years ago, but of equal or greater strength. Just see what this means to the public in the avoidance of hauling a ton and one-half of dead weight with every car moved.

"Let us consider the carrying capacity of the cars. The modern A. R. A. standard 100,000 pound capacity box car weighs approximately thirteen per cent more than the steel underframe cars of 60,000 pound capacity, permitting a revenue load approximately ninety-four per cent greater. In addition the modern car has a cubical capacity to take care of light bulky freight of from thirty-five to seventy-eight per cent greater than the standard box car of thirty years ago.

"Does the public know this, or appreciate just what it means? How many of the public know just what you are doing in the matter of specifications and tests of materials; of the money and time that is being spent on the investigation of power brakes by the railroads; on the work and money you are spending on testing draft gears? Why this effort? Why the time thus spent? Why the expenditure of so much money?

"Take sixty or seventy years ago, when these railroads first started, if the stage coach of that day had been able to travel fifty miles an hour, and if they had had rubber wheels and no shocks and no swamps to go through, and if they could have performed the service for the rate that railroads afterward performed it, you would not have had any railroads. It depends on the way in which you progress and on the adequacy of the service you supply, and on the economy with which you can perform that service, that is what will govern the future of these railways.

"The American people are going today on wheels. There isn't any question about that. And the wheel that goes the cheapest and the smoothest and the most convenient for the public is the wheel that is going to get the business.

"The answer to all transportation problems, as I see it, and the future of the railways, lies in the adequacy of the transportation afforded, and the satisfaction of the public with such transportation. Such satisfaction can best be secured, in my opinion, by a recognition on the part of all these various factors of transportation as to the benefits to be secured to all of them, the greatest cooperative movement possible, and a recognition by each of the advantages of the others.

"When I came in here last night I found piles of packing boxes, chairs upside down, new paint on everything; in fact, there was confusion generally. I said to myself, I wonder if they will ever get this mess straightened out by morning? I had the confidence you would, but when I came in again this morning I saw bowers of flowers, one of the best exhibits of the machinery you people are interested in that has probably ever been gotten together in the world; everything in order, even our friends, the supply people, sitting in their chairs with smiles on their faces. That is railroad efficiency. I do not think any other industry in the country could do a job like that overnight."

Address by Dr. Samuel M. Vauclain, President of the Baldwin Locomotive Works

"It is for the young man in this convention, and the other men, members of it as long as I have been, to put their minds to work, not to find fault with those things which apparently are coming in to drive them out of business, but to embrace those things, enter into them, get the best out of them, apply them to the benefits of the principal business in which they are engaged, namely, railway transportation. We are not going to go out of the railroad business. The Baldwin Locomotive Works are not Division V—Mechanical, at Atlantic City. "We are not going to go out of the locomotive business. I expect that during the next thirty years of my administration of the Baldwin Locomotive Works, we will have accomplished wonders and that the present locomotives, we have

on exhibit here today, which represent, along with others exhibited by our friends, who are in the locomotive business elsewhere, that which is the highest state of the art, as I look at it, or as the railroad man looks at it, or he would not buy them, but they will be a thing of the past before another ten years. And it will be you who will make it so. You will be the cause of it. This association will have much to do with it because these things will be discussed here

"Don't worry about the future and do not have any regrets of the past. The man who thinks about what happened yesterday is not fit to tackle the problems of tomorrow. So what has passed, let it be passed. What have we today? What are we going to have tomorrow? Every day should bring to us something better. There should be something worth having. There should be something to keep a man busy and keep him at work.

"I have just returned from abroad. I have visited many countries and many locomotive workshops. I have ridden on many locomotives, on many lines, and examined into the condition of the motive power, and also of the car equipment. Wherever locomotives are operated abroad they operated very nicely. You seldom hear a clanking rod on these locomotives, but, gentlemen, they are mere 'whispers' as compared to the locomotives you are operating in this country. They are locomotives, of course, but they would be entirely useless so far as the transportation requirements of this country are concerned.

"They, however, are like we are in this country at the present time. We are looking for something greatly in advance of what we are using, something that will be attractive to our railways so that a new business may be created, so that that which is old and which has been used up to the present will be discarded for the better equipment we hope to have in the future.

"In every locomotive-building shop I visited, I found it busy, spending their good money, because they are not making any money on anything else, spending their good money building some particular claptrap with which they expected to captivate railroad managers in the countries in which they existed. All sorts of turbo-locomotives, turbo-electric locomotive, turbo-direct drive locomotives. Then they had all sorts of gas locomotives, direct-drive gas-electrics, magnetic clutch locomotives, and the ordinary gas-electrics.

"In every country I visited I found that they were in the same conditions, or probably a worse condition than we are in this country because we have built some fairly successful gas-electric locomotives.

"The Baldwin Locomotive Works, with which I am connected, as you know, has built one gas-electric locomotive of a thousand horsepower, but we are not ready to sell it to anybody, because I do not think we would want to buy it ourselves just now. We wish to have it a little better, and therefore we will keep on. Ultimately we may be successful.

"But I found that the condition of everybody abroad was that they have come up against the same thing we have come up against in this country, namely, as to whether what we may produce to attract the attention of railway managers will be a commercial possibility. To be successful, an invention, a contrivance, or a machine, whatever you may call it, must be such a one as can be considered commercially by those who are going to use it, so that an extravagant price for anything that is going to replace the present steam locomotive is absolutely out of the question.

"In Russia, however, I rode upon a very successful gas-electric locomotive, designed and built in Germany by Professor Lamonosoff, who, some of you may remember, during war times was here in charge of the Russian equipment. This locomotive is operating on the Moscow-Kirsh line, and is doing very successful work. It has been necessary to build an additional refrigerator to attach to the rear of the engine so as to keep the Diesel engines cool, which, of course, could not be tolerated over here. The locomotive, however, belongs to the government, and the government can do anything to make it successful.

"I was very much amused that they hauled a hotel car along with this engine because the crews are not supposed to work over eight hours a day, and in running a locomotive through five hundred versts, it is necessary to have two extra crews. So they have this hotel car where they sleep and feed the crews until they are ready to use them. I doubt if that would appeal to many of our American railway managers, especially for a machine of only a thousand horsepower.

"Russia, however, in my judgment, has done more and is further ahead with this proposition than we are, or any other country in which these machines are operated. They built them themselves, and they are operating them successfully and satisfactorily, so far as the machine itself is concerned, but I do not think so far as the expense is concerned.

"Now, leaving Europe to take care of itself, and it will have to be left to take care of itself, it will have to continue to use these "whispers" of locomotives instead of real locomotives, because there is not money enough in Europe to change the lines and open up the tunnels, and remove the railway platforms in order to use locomotives of greater size and greater strength. The entire car equipment would have to be changed to accept the American couplers.

"Mr. Ritzatach, who, as minister of railroads, told me that was his chief ambition; to change all the cars in Russia to use the master car builders' coupler, and before he could do that he wanted some American concern to come into Russia and manufacture these couplers there. You know how much chance there is for that. That is an impossible thing to accomplish until the Russian government changes its attitude and recognizes property rights, and is willing to restore to all American citizens all the legal property which they possessed in Russia prior to the revolution. It must do something also that will lead every American citizen to understand that no further communistic propaganda would be advanced in this country in any way, either directly by the Russian government, or by the Internationals, which has its headquarters in Petrograd.

"Therefore, Russia will have to wait. She will have to wait until she changes her mind. And everybody has a right to change his mind, you know. We can't keep on forever thinking one thing. If we did, we would never prosper. We would never progress. Russia will progress, in my judgment, and that very quickly.

"One reason why this famine of industry prevails throughout all countries of Europe is that all the military operations have ceased. The millions of people who were employed in the manufacture of war machinery of all kinds are out of work, and there is not sufficient commercial activities there in their own country, or in the countries which they adjoin to give these people employment. Therefore, until the wall is torn down and the great country of Russia is opened up to western Europe, their troubles and their poverty will not come to an end.

"Here in our country, what do we see? We see the greatest prosperity that any country has ever enjoyed. We see a nation, built up upon a solid foundation, a foundation built by its own people. We are a very autocratic government here. It is autocratic because it is govern-

ment of the people. The people make their own laws, and then the people compel themselves to obey those laws. There is an autocracy that is apparent wherever you go in the humblest walks of life, or in the highest planes, which we enjoy in our present civilization.

"This present prosperity is due to what? It is due to the tireless energy of the transportation people of this country that has made it possible for the people of a great nation of more than one hundred million people to communicate with one another, to have business relations with each other in an almost inconceivable space of time.

"We are all as though we lived on one lot, notwithstanding that this lot is three thousand miles wide. No one thinks of distance. No one thinks of the difficulties so far as they relate to the transportation of goods or to the transportation of people.

"This transportation of the railways has incited additional transportation facilities. The gasoline man has come along with his automobile.

"Automobile buses are the next thing that have come along. People have said, 'Why these buses are going to drive the railroads out of business.' Gentlemen, don't worry about the automobile buses. It is going to drive you into business. In another ten years, the railroads will hardly know, unless they increase their facilities very much, how to handle this tremendous business that will be built up by the cross lines operated by automobile buses, automobile trucks, everything that can run anywhere without a rail, no matter what it costs. Railroad facilities must be increased.

"The American people don't care for the cost at all: what they want is to be on wheels. If it is not on car wheels or locomotive wheels, it can be bus wheels or automobile wheels.

"Don't look backward; look forward. That is the only hope for the American people, to keep progressing. Don't worry about the people on the other side of the water. Let them take care of themselves. They are able to do it. They have been at it for centuries and we have been at it for one.

"Let us go ahead and develop our own country. Let us develop our own facilities. Let us introduce the human idea into the work we do. Let us take care of the man who has to work eight or ten hours every day, or probably sixteen, at low wage. Let us do everything we can to increase his wage; make it higher. Give him more opportunity to enjoy life, so that he can provide greater privileges for his own family, but, at the same time, by your own ingenuity, by the development of mechanical devices, reduce the cost of production so that we can all enjoy that which we have to deal with here in this great United States."

Committee Report on Design of Shop and Engine Termina

Submits Layout for Freight Car Repair Shops

The committee of which W. A. Callison, superintendent of motive power of the Chicago Indianapolis & Louisville Ry., was chairman, submitted a study of a layout for freight car repair shops.

It is only within the last few years that particular attention has been directed to the routing or progressive movement systems for repairing cars. Such systems for manufacturing cars and locomotives, and automobiles and trucks, have been used for a considerable length of time. Recently, however, the so-called progressive system of freight car repairs has been installed in a number of railroad shops and excellent results have been reported. Your Committee, after visiting a number of up-to-date freight car repair plants, including manufacturers' shops, finds almost a unanimous recommendation for the progressive type shop layout.

The advantages incident to scheduling and routing material and operations co-ordinated with progressive movement of the car through the shop, are now well known and have been presented to the Association in former papers covering this subject in detail. The necessary segregation of the shop organization into groups specializing on particular jobs in progressive order is an important feature of the routing plan. This will be referred to later. The progressive movement system lends itself to freight cars more readily than to passenger cars, for the reason that it would not be good practice to move passenger cars from position to position as is done with freight cars.

A survey of the freight equipment owned by Class 1 railroads showed a total of 680,685 all steel, and 992,212 steel underframe, or a total of 1,672,897 cars which will need to be repaired. The total of all freight equipment owned by Class 1 railroads is given as 2,345,591 cars (report ofr December 31, 1925). These cars will be coming in for general overhauling or rebuilding in increasing numbers from year to year. This is one of the reasons your Committee has seriously considered the requirements for a steel car repair shop.

Freight Car Repair Shop

The plan included in this report shows a general layout for a modern freight car repair shop. In presenting this plan the Committee has, to some extent, incorporated the best features and ideas practiced by the several shops visited and attention has been given to articles in technical papers and other sources, sovering this subject.

This shop is six hundred (600) feet long by two hundred ten (210) feet wide and has room, or capacity, for standing forty-five (45) cars. There are two central stripping (incoming) tracks and four repair (outgoing) tracks; these are shown in pairs near the outer longitudinal sides of the shop. The planing mill, dry kiln and lumber storage are shown at one side and the truck and wheel shop at the incoming end of the main repair shop. The machinery bay, or fabricating shop, is between the incoming tracks. When designing this layout, the Committee felt that a shop suitable for the larger roads should be presented. This plan provides some flexibility to accommodate the needs of either large or small roads and can be adjusted easily without altering the general scheme.

Referring again to the general plan. It will be noted that composite or box cars are indicated going out on the two tracks adjacent to the lumber supplies and all steel cars are run through on the two tracks on the opposite side of the shop. This arrangement is not fixed and cars of any type desired may be run through on any track available. For the best routing operation, cars should be placed in shop segregated by classes and the above mentioned system followed. Where cars of the same type or series are sent to the shops periodically, the maximum efficiency and output can be obtained.

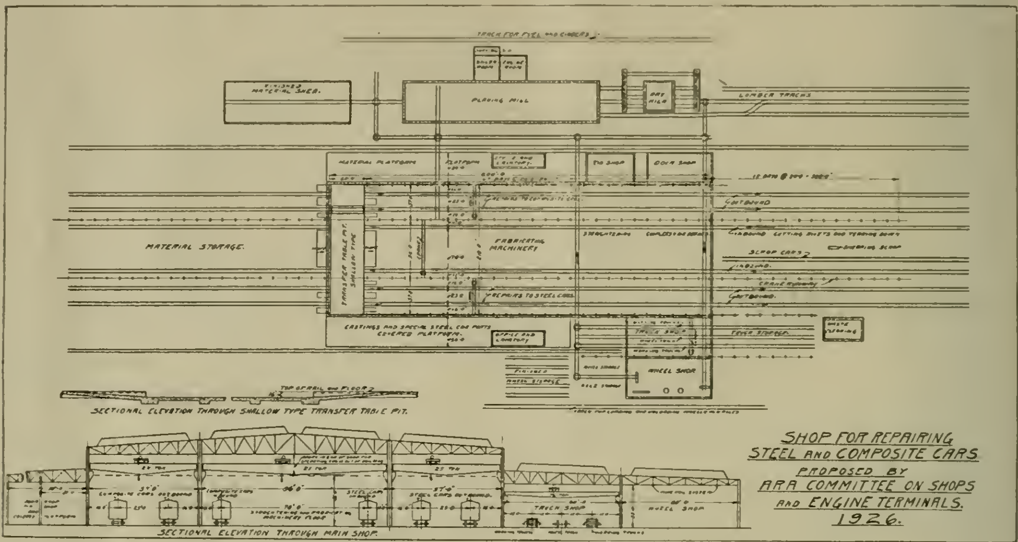
The planing mill is indicated on the layout, but no

details are shown for the reason that in many cases one mill serves both passenger and freight shops. A planing mill for passenger car shops is described on page seven of the report of this Committee for 1925; the lumber yard and dry kiln are also mentioned, and a passenger car wheel shop is outlined on page six ot the 1925 report. The repair shop, truck shop, wheel shop, pipe, air brake and fabricating shops, paint shops, and storehouse will now be briefly described in order.

Repair Shop—Progressive Movement

The general operating method will now be described briefly. Cars enter the shop on the central or stripping tracks after all rivet heads have been cut and rivets backed out. Scrap sheets are removed outside the shop wood or composite cars has been mentioned, that is, on the planing mill side of the shop. The car proceeds, hauled as necessary by pullers, to the fabricating position where gangs fit and key-up all sheets ready for riveters. This work includes floors, cross ridge sheets, doors, etc. The next movement of car provides work for riveters and all riveting is done at this station. Underframes removed and repaired or renewed will require some special treatment, but this will in no way interfere with a continuous method of operation. The next movement of car is for application of trucks, safety appliances, draft gears, couplers and brake equipment. Painting and stencilling are performed in the paint shop. Stencilling may be done in the yard, in good weather, if desired.

From the above suggested routing scheme, under the



Details of Car Repair Shop Proposed by Committee of the American Railway Association

and good sheets loaded in same cars, or left in place with ("tack rivets"), as the situation requires. At this point, it may be well to mention that it is the intention to handle scrap direct from docks to destination. Suitable facilities are provided to accomplish this both for metal and wood scrap.

Having entered the repair shops, the first operation would be to remove and repair the trucks or replace them with repaired trucks in kind; or trucks may be allowed to remain under the car until it reaches this section of the shop on its outward movement when trucks can be replaced in kind or removed and repaired. The next operation is to remove all couplers, draft rigging and air brake equipment as may be found necessary; and doors, etc., in the case of wood or composite box cars. The next movement of car provides facilities for taking off the sheets and doors for straightening or repair. The underframe may be removed and straightened or repaired next if necessary, but the large majority of repairs will not require this. Arriving at end of shop, the car is switched by a transfer table to one of the outgoing tracks. This transfer table is of the shallow pit type so as not to block trucking and other traffic through the shop. If the shop is not worked to capacity, the inside outgoing tracks should be favored as they are nearest to the central machinery bays. The best route for

progressive system, it is seen that your Committee has taken what seems to be the best of modern car shop practices and so adapted them to this shop layout that the least possible movement of men or material is experienced throughout the entire repair program. In general, cars come in on one track and drop parts in order at stages where the repairs to these parts take place and when the car returns on its outward trip, these same parts are picked up in reverse order and applied to car as it passes these respective repair stations.

Truck and Wheel Shop

After the trucks are removed from the cars they are taken on the cross track shown on the print to the truck shop where a 7½-ton overhead crane places them upon the truck storage tracks. This same crane brings the trucks into the shop and after being repaired, the trucks pass out the opposite end of the truck shop to the truck storage platform and thence into the main shop at the cross track shown. Wheels taken from the trucks are run into the wheel shop and dismounted. The wheel shop is also so situated that wheels and axles can be unloaded from cars immediately adjacent to it, and after being run into the shop, the mounted wheels are placed on the finished wheel storage until they are needed in the truck shop.

After the trucks go into the truck shop the waste is removed and sent to the waste cleaning facilities for reworking. The cleaned waste is available for packing the cellars of the outbound cars.

Storehouse and Material Storage

The location and arrangement of the central store plant is not shown as its location and arrangement will depend upon the facilities involved other than the car repair plant. However, much of the material that will be used in this plant is stored adjacent to it. Steel plates and other steel sections are stored both outside and inside of the building near the transfer table end where these materials are under the crane and can be easily transported to the fabricating machinery.

On the steel side of the shop is located a platform for special steel car parts and also material for the truck shop.

On the wood side of the shop is a material platform for the storage of finished material for wood cars—also, grab irons, bolts, nuts, washers and all miscellaneous small castings.

These platforms may be covered or left open depending upon the climatic conditions of the locality in which the shop is situated.

While we have designated a steel and wood side to the shop, it can be worked as all steel or wood if necessary. Our thought was to provide a shop that would meet an average situation.

In this report, your Committee has endeavored to indicate in a general way what in our judgment, is a desirable arrangement for repairing steel cars with sufficient flexibility for handling composite, house and other types. This lay-out might have to be modified somewhat to meet local conditions.

Some study has also been given of a shop providing for continuous movement of cars, in one end and out the other end as a finished product, but we did not have sufficient time to enable us to present it properly in the report of this year.

Developments in Wrought Steel Wheels

Committee Report on Wheels, C. T. Ripley, Chief Mechanical Engineer, A. T. & S. F. Ry., Chairman

As a result of the work of the Technical Committee of the Wrought Steel Wheel Manufacturers there has been an extensive study made of possible changes in their product to overcome the shelling trouble which has been experienced. A number of tests of steel wheels made by special processes are now under way on various railroads. Some of these tests are being run by roads represented on the Wheel Committee. In the case of those being run on other roads, the Committee will attempt to secure the test results in order to cooperate with the manufacturers in arriving at conclusions. These special processes are as follows: (1) Turning off of ⅜ in. or more of tread metal of wheels by manufacturer. (Data available indicated that the majority of the shelling occurred on the first run of the wheels.) (2) Water treatment process of rim of wheels. (3) Manganese Steel Wheels. (4) Wheels with tread surface cold rolled. All of these tests are of such recent date that no figures are available for report this year but it is believed that the tests are so comprehensive that the information resulting from them will enable the manufacturers to make further advance in the quality of their product.

Another development in steel wheels is that of the so-called one wear steel wheel. This wheel has only about one-half inch of service metal in the tread. The plate and hub are also lighter than the multiple wear wheel. The proposal of the manufacturers is that this wheel will be used only in freight cars with journals not over 5½ in. x 10 in., and scrapped after its one period of service. The relative advantages of this wheel as compared with the multiple wear are claimed to be a matter of cost and the individual railroads must work this out from their own service results. We understand that one of the roads has applied a large number of these wheels. The code of rules was revised to provide for the use of this new type of wheel in interchange. It was impossible to handle the billing of this wheel on the same basis as the multiple wear wheel, and it was, therefore, considered in the same way as other single wear wheels, that is a new value, a secondhand value and a scrapping value were assigned. It was made to come under the provisions of the remount gage to avoid the billing of practically worn out wheels as secondhand. Furthermore for protection of the multiple wear wheels users the rules provide that the one wear wheel cannot be applied in place of the multiple wear type, although multiple wear wrought steel wheels may be applied in replacement of the so-called one-wear wheels.

The Technical Committee of the Wrought Steel Wheel Manufacturers has submitted to your Committee a specification for the so-called one wear steel wheel with the statement that these wheels are being manufactured by one company only and that the specifications are, therefore, tentative since the Committee is not yet in a position to submit final agreed on specifications. The Wheel Committee is not satisfied with these specifications. They feel that the tolerances are rather liberal and that the requirements as to finish are not what they should be. If these wheels come into general use it will probably be necessary for the Wheel Committee to submit to the Association a set of specifications governing their manufacture and by that time the manufacturers themselves will probably be in a better position to make recommendations as to specifications.

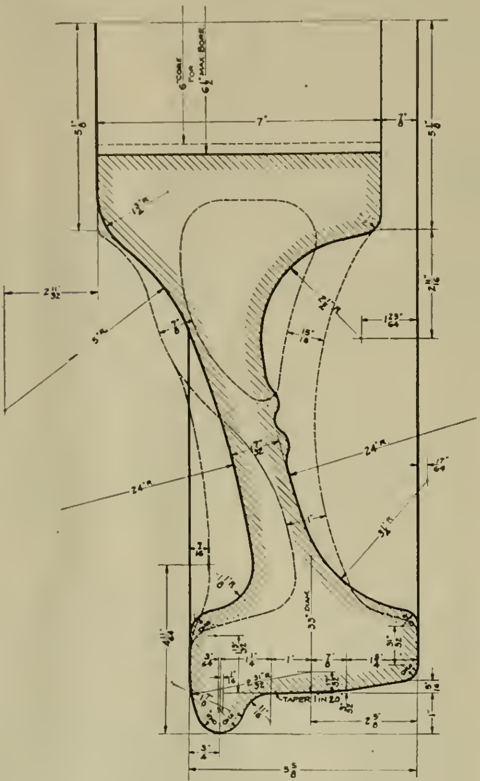
In last year's report the Committee called attention to three developments in cast iron wheel design, the lip chiller, the reinforcement ring plate and the single plate. They have been following tests of these three features during the past year and all of them are showing interesting results.

Wheels made with the lip chiller, which eliminates the sand rim, have come into general use and all of the reports available indicate that they are effective in reducing the number of wheels condemned for chipped rim. Small pieces do chip or cut out of these rims, due to striking special frogs, etc., but they seldom develop the long leaf-like fractures which are such a common cause of condemning of wheels. Some trouble has been experienced by the foundries, due to getting a somewhat deeper chill at the outside of the rim when lip chillers are used. It does not appear that this is a particular drawback as there is no danger to the wheel involved. It is felt that the lip chill wheel will prove a considerable saving to the railroads.

About eighteen months ago a thousand reinforcement ring plate wheels were placed in service on refrigerator

cars on one of the roads. Only one of these wheels has developed a broken plate and in this case the break stayed inside of the ring instead of going out through the rim and thus derailment was avoided. This would indicate that the rings were a helpful feature of design, due to their collection of impurities in the metal. However, the single plate design, which will be discussed in the next paragraph, apparently takes care of this same defect in wheels in a still better manner.

The design development which promises the greatest improvement in cast iron wheel service is the single plate. The illustration shows such a design superimposed on a standard double plate type. The elimination of the pan-core seems to give a much cleaner metal in the plate and the thicker plate resulting from the concentration of the metal in the plate due



Single Plate, 700-lb. Cast Iron Wheel

to the elimination of the brackets appears to make the wheel much better able to withstand the stresses produced by brake shoe heat at the rim. A considerable number of thermal tests have been made of these wheels and they appear to stand this test much better than the standard A. R. A. design. Reports from those roads which have been testing out the 850 lb. single plate wheel in tender service, indicate very satisfactory service. So far as the committee is informed there have been no cases of cracked plates in these wheels. The manufacturers have now developed the 650 lb., the 700 lb., and the 750 lb. single plate design. One thousand of these wheels have been placed in refrigerator car service by one of the roads and data as to their performance should be available in another year. These wheels are up to standard A.R.A. weight and meet all specification requirements but the manufacturers are not putting them out generally but only for test as authorized by the General Committee. It is proper to mark these wheels A.R.A. just as wheels with special tread and flange contours may be marked A.R.A., but the letter "X" is placed after the A.R.A. to denote that they are experimental designs.

Cast Iron Wheel Specifications

It was the intention of the Committee to give consideration to the revision of the cast iron wheel specifications, and it was the plan of the manufacturers to make a series of recommendations to the Committee, particularly as regards the chemical specifications and increase in the thermal tests. Due to the lack of time these recommendations were not received and the subject will be carried over for the next year's work of the Committee.

Grinding of Wheels

There has been considerable interest shown by various railroads during the past year in the grinding of slid-flat cast iron wheels but so far as the Committee knows no large grinders have been installed. Some controversy has developed between roads as to interchange billing for secondhand wheels which have been ground. The Committee was asked to give an opinion on this matter and they reported to the Arbitration Committee as follows: "The Wheel Committee feels that the only specification necessary on reground wheels to make them proper for billing as secondhand is that they cannot be condemned by the remount gage and that the wheels have been ground in a type of machine which grinds the entire circumference of the wheel truly concentric with the journal." The experience of the Committee in witnessing and checking the grinding of cast iron wheels causes it to look very favorably upon this procedure and they can see no reason why a reground wheel is not equal to the average secondhand wheel and as a matter of fact they are ordinarily superior to such secondhand wheels because they are truly round and the tread is free from heat checks. With proper grinding machine practice, only the best wheels are selected for grinding.

During the past year a number of portable grinding machines have been put in service. These machines, which are mounted on the journal of the axle, merely lengthen out the flat spot by grinding off the edges. Your Committee feels that this is an undesirable practice as it leaves the wheel out of round which is detrimental, both to track and equipment. The only proper procedure is to grind the entire circumference.

The Committee wishes to again make the recommendation that the railroads give more consideration to the installation of grinding machines of the proper type for reclaiming slid-flat cast iron wheels. The possibilities of savings have been fully demonstrated in previous reports of this Committee. The advantage has also been shown of the practice of grinding new cast iron wheels after mounting, in order to secure rotundity. Savings are also possible in the grinding of slid-flat steel wheels. It is recommended that the grinding of slid-flat cast iron, cast steel and one wear wrought steel wheels in the types of grinding machines which grind the entire circumference of the wheel truly concentric with the journal be made the recommended practice of the Association.

Wheel Mounting Gage

In last year's report a drawing was shown of a suggested gage for use in the mounting of steel wheels. Further study of the use of this gage has been made

and the Committee has come to the conclusion that it would be better to have the back to back of flange measurement on the gage 4 ft. 5¼ ins. instead of the 4 ft. 5 3/32 ins. shown. The I. C. C. maximum limit on tank wheels is 4 ft. 5⅜ ins. The Committee has, therefore, prepared another sketch making this change. It is still felt that the proper way to mount steel wheels is to use the back to back basic measurement. This is particularly necessary where the road follows the practice of dismounting worn flange wheels and re-mating with other worn flange wheels in order to save tread metal of mate wheels.

The standard A. R. A. gage for mounting cast iron wheels has been subjected to much criticism because of the difficulty in using it in mounting two maximum flange wheels or wheels where the tread wear results in maximum flange. Difficulty is also experienced because of the inadaptability of the gage for use on reinforced flange wheels which are being used by a number of roads. It appears that it is the practice on some of these roads to cut 1/31 in. off the flange face bearing surface at each end of the gage in order to make the gage serviceable on this type of wheel. When such wheels are applied under a foreign car and the owning road attempts to check the mounting with their standard gage they naturally find that the wheels are not properly mounted. This is a situation which should be corrected in some way. The suggestion has been made that the standard gage be changed by cutting 1/32 in. off at both ends as mentioned above. From a track viewpoint this seems desirable as the mounting of the wheels closer to the rail should produce less rail wear and it may also be desirable from a flange wear viewpoint. Your Committee feels that this is a subject of such importance that a very careful study of all the features involved is necessary and is, therefore, not willing to make definite recommendations at this time but will study the matter further during the coming year.

Use of Remount Gage

Last year the remount gage requirements were changed so as to make a lesser restriction on the gaging of secondhand wheels. We have no recommendations to make as to any changes in these gages so far as their use for billing is concerned, except to say that every effort should be used by all of the railroads to check all secondhand wheels applied to foreign cars with these gages. This will avoid any unfairness in the billing of such wheels.

Gaging of Chipped Rim Cast Iron Wheels

One of the commonest causes for condemnation of cast iron wheels is the chipped rim, Rule No. 78. There appears to be a general misunderstanding of this rule, and wheels are being condemned under it which are absolutely safe for operation. For example there may be a small surface flake which falls within the 3¾ in. limit. Such wheels should be allowed to run. Generally speaking the defect should come under the gage for a length of at least 2½ in. although there may be exceptional cases of heavy breaks which are not this long and yet require condemnation. The Committee recommends that the inspectors be instructed to use more judgment in handling this defect.

Loose Wheels

A number of reports have been made to your Committee in regard to wheels found with indications of being loose on axle but which, when put in the dismounting press, showed proper pressure in fit. Indications referred to were the showing of oil working out at the inside of the fit. This condition is undoubtedly causing a considerable amount of unnecessary wheel work and most of it can be avoided if proper material is used for covering the wheel seat when the wheels are mounted. The trouble is that some wheel shops are using a thin oil or a paint thinned down with light oil. The proper material to use is a mixture of white lead and linseed oil. Part of this poor workmanship may be found in the wheel shops of the car manufacturers as there seems to be a lack of understanding of the importance of using a proper material for covering the axle wheel seats when the wheels are mounted. It is important that all roads check this matter and put a stop to the practice which is resulting in additional trouble and expense, both on their own and foreign roads.

Vertical Flange Defect

There are a large number of cast iron wheels condemned under the vertical flange Rule No. 74. Many of these wheels are not truly condemnable when the gage is properly applied. In order to take the gage the flange must come in contact with the limit point of the gage and not as some inspectors interpret it, merely have a flat surface to the limit height. Furthermore the gage when used to measure the ⅞ in. vertical limit gives in some cases an incorrect result, due to cocking of the gage in the worn tread of the wheel. To overcome this a notch may be cut in the long side of the gage at a ⅞ in. height. The gage can then be applied on its narrow edge which will overcome the effect of the hollowness of the tread and will not interfere with the use of the present notch at one inch.

Wheel Mounting Pressure Tables

There has been considerable criticism of the wheel mounting pressure tables. The members of the Wheel Committee have made a check of this matter in the railroad shops. It was found that when pressure recording gages are used it is practically impossible to stay within the limits set up by the table even though micrometer gaging is used and the general practice is to run above the limits, as this is felt to be the safe side. The Committee feels that any such tables should be practical and that their effect is nullified if the shops are permitted to exceed them in either direction. Furthermore there is a general feeling that it is better to use a somewhat higher pressure in the mounting of steel wheels. In consequence of this investigation your Committee recommends that the wheel pressure mounting tables be revised as follows:

Size of Journal	Old Table A. R. A. Standard	New Table A. R. A. Standard
	Steel Wheels	
3¾x 7 ins.	45—60 Tons	50— 70 Tons
4¼x 8 ins.	50—70 Tons	55— 80 Tons
5 x 9 ins.	60—80 Tons	70—100 Tons
5½x10 ins.	65—85 Tons	75—110 Tons
6 x11 ins.	70—95 Tons	80—120 Tons
6½x12 ins.	....	85—130 Tons
	Cast Iron Wheels	
3¾x 7 ins.	30—45 Tons	30—55 Tons
4¼x 8 ins.	35—50 Tons	35—60 Tons
5 x 9 ins.	40—60 Tons	40—65 Tons
5½x10 ins.	45—65 Tons	45—70 Tons
6 x11 ins.	50—70 Tons	50—75 Tons

This change will permit establishment of absolute limits, a desirable improvement over present practice in many shops. The machining of the axle wheel seat and the wheel bore must be done in a workmanlike manner and a recording pressure gage should be used on all wheel presses. The pressure should increase uniformly as the wheel is pressed into place on the axle.

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The Atlantic City Conventions

That the work of the Mechanical Division of the American Railway Association is becoming more valuable year by year needs no other evidence than a brief glance at the addresses and reports presented to the convention this year and extracts of which are reviewed elsewhere in these columns. The conventions last month were well attended and the work done was equally important to the business performed at any of the numerous meetings held since the organization of the Railway Master Mechanics and Railway Car Builders' Associations.

The questions discussed at the meetings were of the utmost importance in their various departments. They have been met and mastered in a manner that would have been impossible in the case of minds working separately and at remote distances.

There was a magnificent display of locomotives, cars, and machinery for increasing efficiency in the shops. All of immense educational value and interest to railway mechanical engineers and those responsible for the operation of American railways.

A prominent motive power officer declared that "If any one had a doubt as to what the railroads mean to the manufacturing interests of the country and their stimulus to mechanical genius, he or they, ought to attend one of the meetings of the Mechanical Section of the American Railway Association and then drop into the display or exhibit section of the Railway Supply Manufacturers' Association; the conventions were fine and we all learned something."

The Steam Engine Indicator

The value of the steam engine indicator is so well recognized by engineers that it seems almost like begging the question to offer anything in its defense or praise, yet there are not a few engineers who, like backsliding Christians, must be periodically reminded or reconverted to a well known fundamental truth.

It has recently been stated by one of wide experience in this particular field of railway engineering, that by an intelligent use of the steam indicator on locomotives, and profiting by the lessons to be learned, that a saving of more than $1,000,000 annually could easily be effected in fuel and increased engine efficiency. Very little is being done in this particular line, yet in most places there exists the greatest opportunity and need for improvements. The use of the steam engine indicator would yield immediate returns, yet there seems to be an attitude of indifference to this subject, while much activity is displayed with respect to other matters of much less importance.

In the February, 1924, issue of Railway and Locomotive Engineering this matter was not only strongly urged as the one important channel through which great improvements could be made and much economy effected, but the claims and suggestions made were fully simplified and supported with a series of indicator diagrams that in themselves spoke volumes. Again, in the August, 1924, issue of this paper the matter was presented in pretty much the same manner. The way was clearly shown in the articles referred to whereby millions could be saved in the fuel account, and the potential value or efficiency of engines very materially enhanced through the use of the indicator.

To those who make light of the value of scientific research or use of mathematical instruments in attaining higher efficiency in locomotive design or operating economy, an object lesson or two might serve a good purpose.

A certain railway company bought ten new locomotives, that, while doing pretty well at slow speeds seemed to be loggy or "lay down" as it were when pressed for speed. During the first year of their service thousands of dollars were spent on these engines in making adjustments, changing lap and lead of valves, position of eccentric, new valves of various dimensions, etc., etc. All to no avail; they just simply began to slow up or "lay down" when crowded to speeds above 30 to 35 miles per hour. Finally, after all the valve setting experts and other skilled mechanics had failed to locate and remedy the trouble, one of these engines was quite badly damaged in a head-on collision, requiring new steam pipes, steam chests, cylinder patches, etc. When again put in service it was found to be worse than before. The valves were accurately adjusted by a skilled valve setter. The engine not only displayed its former tendency to "lay down" when crowded for speed, but with such increase in speed as was attained the engine increasingly limped indicating a distorted valve adjustment, after having been repeatedly gone over and checked by experts.

The superintendent of motive power who rather prided himself on his superior knowledge of valve motion, ordered the engine into the shop, declared he was sick and tired of all this nonsense and that HE would now set the valves on this engine. He did, and when the engine was again placed in service and attained a speed of 15 to 20 miles per hour, the exhaust seemed to mock the superintendent of motive power with a hip-ity-hop sound, and was worse than before. Well, something had to be done, and while there was loud talk of sending the engines all back to the builders, a man suggested "trying the indicator." To this proposition there were various reactions,

from that of the back shop foreman and expert valve setter, who said he would suggest trying out a good sized monkey wrench on the head of any man who would make such a fool proposition, to the superintendent of motive power who vehemently declared that this was no time for foolishness and that he would not be a party to or allow "a balky horse" (the defective engine) to be decorated with silver mounted instruments as a reward for its failure and his own chagrin. He was going to make the builders fix that lame duck at once or he would take steps to have all ten engines sent back.

Well, after several rebuffs the superintendent of motive power was induced to allow the balky horse to be decorated with a nickel-plated mathematical instrument, care being taken to prevent the general foreman from trying out a good sized "monkey wrench" on the operators head during the operation, as he had expressed a desire to do, and here is what was found to be the trouble.

The M. E. P. dropped very fast as the engine attained a speed of 15 to 20 m.p.h., and at 30 to 35 m.p.h. one cylinder was doing less than one quarter of the work. The steam pipe on that side was removed and it was found that in casting this pipe, quite a large piece of the core had dropped out, thus causing an obstruction in the steam pipe, which at the higher speeds practically robbed this cylinder of sufficient steam to render effective work and obviously caused the "hip-ity-hop exhaust. With this trouble remedied, it was then found that the live steam passages in all the cylinders were cored too small, which accounted for the loggy action of all the engines at the higher rates of speed.

The builders replaced the cylinders with new ones having ample steam passages, and the trouble was entirely remedied, all through the intelligent use of the steam indicator. More than a year's trouble, turmoil, expense and loss of efficiency of ten new engines might have been almost entirely avoided by the prompt use of an indicator at the first symptoms or evidence of deficiency.

The field is broad and inviting and if properly exploited will yield millions in returns.

The Careful Grade Crossing Campaign

During the last ten years more than 19,000 persons have been killed and over 52,000 injured at grade crossings in this country. There are over 20,000,000 automobiles registered in the United States and they operate on every highway.

It is the reckless class of automobile drivers that persist in taking chances that contribute the greatest number of accidents registered each year.

The railroad and public officials are bending every effort to reduce this total by a Careful Crossing Campaign conducted under the auspices of the American Railway Association during the summer months of each year. This brings to the attention of the people the necessity for exercising the greatest possible care to avoid being struck and killed or injured by trains while traveling over crossings and impresses upon locomotive engineers, firemen, brakemen and all other employes the necessity for doing everything within their power to prevent such accidents.

That the railroads are doing their part in safety of operation is shown by reduction of the hazards of railroad travel by one-half in a decade. Records of the Museum of Safety show that one passenger was killed for every 6,620,000 locomotive miles and one injured for every 116,000 in 1914. In 1924 after ten years of systematized effort to improve conditions for figures stood at one passenger killed for every 11,250,000 locomotive miles, and one injured for every 287,000 locomotive miles. If automobile casualties could be reckoned on a car mile basis they might show a tendency to decline. Available statistics, however, reveal no such trend. If automobile drivers did not try to cross tracks until it was safe to do so, approach crossings with their automobile under full control, and be alert for approaching trains there would be few accidents.

Even if the money was available to eliminate all crossings at grade and the public willing to pay for them, many years would be required to do the work. Protection from the peril for the present generation, at least, can only come from "Crossing Grades Cautiously."

Trains cannot stop at every crossing if they are to sustain the speed expected by the public. The train crosses a highway about every half mile or so, but a motorist encounters a railroad only occasionally.

Efforts by the railroads to reduce crossing fatalities and injuries are bearing fruit, and locomotive engineers are doing their part by proper use of the whistle and bell. Never in the history of railroading has there been stricter observance of giving signals at crossing than right now.

Training Apprentices for Skilled Workmen

The Chamber of Commerce of the United States has recently issued a warning that a shortage of skilled workmen will continue to exist unless a more concerted effort is made by employers to train apprentices, which is based on a nation-wide investigation. Employers should realize the need of training skilled workmen to meet the growing demands of industry generally as restricted emigration has reduced the former supply of trained man power. There is a tendency for boys to drift toward clerical positions and office jobs. This tendency is many times not justified by the opportunities to advance, but shows a neglect on the part of industry to sell the opportunities afforded the trained man in the shop. Thus a shortage of trained man-power will continue to confront industry unless something is done about it.

There is ample evidence that little has been done to interest the sons of employes—the coming generation. The business which employs the father may and most frequently does offer a worthwhile opportunity for the sons.

As in everything else since the earlier days apprenticeship has changed to meet changing conditions and demands. Notwithstanding the great growth of labor saving and automatic machinery there is yet ample room for brains and skill in industry. American business men can do nothing more important than the educating and training of the young men whose greatest prospects of success lie along industrial lines. Not only does apprentice training provide a valuable source of supply from which foremen may be drawn, and later on executives, but it creates a supply of trained men—dependable, efficient and capable workmen. It offers opportunity to promote men policies and the ideals of the company. It reduces labor from within the organization who are familiar with the turnover through loyalty. It supplies skilled artisans and workmen to meet the effect of restricted immigration.

Learning a Trade

We are frequently consulted by the parents of young men about the propriety of their sons learning a mechanical trade and the question is often asked what will be the prospects of the youth for success in life after he has spent four or five years learning the trade? The father also asks, would his prospects not be better if my boy learned pattern making instead of the machinist trade, since pattern making is better paid.

As a rule, the highest wages are paid in those trades

that are most difficult of mastery, and the ability to master a trade should have something to do with the advisability of attempting to learn it. This, however, is a difficult and delicate question to decide upon. While in some trades less wages as a rule are paid than in others, there is in most of them always "room at the top" with good wages for those that get there.

The pattern makers' trade is a good one for those who have the industry and performance to thoroughly master it, which implies a good deal more than will be learned in a workshop. A first class pattern maker acquires more technical knowledge than the ordinary machinist requires to know, although every machininst who understands the science of his business is likely to succeed better than the man who cares nothing for knowledge. The pattern maker should know a good deal of geometry, some of which he may learn from books but some of which he must invent. The same may be said of machinists, moulders, boiler makers and other mechanics. In all trades those who read and study the literature of their calling are most likely to work towards the top. The lazy, indifferent mechanics gradually drift towards their natural place—the bottom.

Promotion of Railroad Safety

A survey of the safety programs in the leading industries of the country by the American Engineering Council discloses that twenty-eight Class I railroads have succeeded in reducing by 35 per cent or more the number of accidents to persons. The decrease in casualities comes as the result of a two-year contest against loss of life started by the safety section of the American Railway Association in 1924. The Association hopes to establish a 35 per cent decrease on all the railroads of the country by 1930.

The fact that in two years 28 lines have already attained the reduction quota is regarded by the engineers as proof that, with the co-operation of employes and executives, industrial accidents of all kinds can be largely eliminated and a new era of safety inaugurated.

L. R. Palmer of New York City, conservation engineer of the Equitable Life Assurance Society and vice-president of the National Safety Council, compiled the figures which were given out recently by Dean Dexter S. Kimball of Cornell University. Dean Kimball is president of the American Engineering Council.

Test of Radio Telephony on Freight Trains by New York Central

Tests of two-way radio telephone communication as an aid to operation of freight trains, are being conducted by the New York Central Railroad. These tests already made on the Western Division of the New York Central between Elkhart and Pinola, Ind., have demonstrated clearly that successful radio telephone service can be maintained between conductor or brakeman in the caboose and the engineman or fireman on the engine of freight trains up to 100 or more cars in length.

In the tests a New York Central freight train, consisting of engine 2626 with 11 cars and caboose, was used. The train started from Elkhart at 4 P.M. and for five hours continuous and satisfactory radio telephone conversation was carried on between the railroad men in the caboose and those on the engine. In this period there occurred a severe electrical and rain storm, but despite this, the radio telephone conversations were clearly audible and no interference was experienced. There was no severance of communication around curves or when the train was midway beneath beneath steel bridges. The passing of other train on adjacent tracks also did not interfere.

A special test to determine the value of the radio should the train break in two, such as occasionally happens in 100-car freight trains that are now frequently operated, was made. The train was stopped at Hudson Lake, Ind., and the locomotive was detached, and run ahead to a point just east of Rolling Prairie, four miles distant. Throughout the entire distance communication was maintained readily with the engine and always with good loud speaker volume. Equally good results were obtained when the engine was stopped and while it was backing up to be coupled to the train.

The preliminary tests are being made by the New York Central in co-operation with the Zenith Radio Corporation of Chicago and under the sponsorship of the Telegraph and Telephone Section of the American Railway Association. The trainmaster, conductor, engineman and trainmen who used the sets are all enthusiastic as to the success and practical utility of the radio in train operation. These tests indicate that radio telephony will probably prove to be a wonderful aid in the handling of freight trains as well as in general train operations.

The radio equipment placed on both the engine and caboose consisted of special receiving-transmitting sets (made by the Zenith Radio Corporation of Chicago), with the necessary motor generator, batteries and loud speaking receiver. An antennae consisting of 32 feet of ½ inch brass pipe supported on special brackets located 12 inches above the cab roof, was installed on the engine. The antennae on the caboose consisted of 32 feet of rubber-insulated wire mounted on supports. The special transmitting-receiving sets contained seven tubes—three for transmitting and four for receiving. The transmitting tubes consist of 50-watt oscillator, 50-watt modulator and 7½-watts for speech amplification. A wave length of 115 meters was employed.

Where Freight Rates and Passenger Fares Go

A calendar showing where freight rates and passenger fares go, has just been published by the Committee on Public Relations of the Eastern Railroad. It is the work of Charles S. Chapman, a prominent member of the National Academy. The original of this calendar, printed in color, is of a large poster size—27½ x 42⅛ inches. It will be displayed in stations and elsewhere generally by the Eastern railroads this summer.

The basic facts used in the calendar were arrived at in the following way: The aggregate gross operating revenues of Class I railroads was divided by the 365 days in the year; in this manner it was possible to show in terms of daily gross receipts the number of days taken by each item of railway expenditure.

This shows that out of the gross revenues of the year 157 days went for wages; 27 days for locomotive fuel; 70 days for materials and supplies; 24 days for all other operating expenses; 21 days for taxes; 41 days for interest and rents (fixed charges); 19 days for dividends; and 6 days for improvements purchased out of earnings or to make up losses of former years—or to help create reserves against bad years in the future.

The railroad calendar is based upon the operating figures for 1924, as the necessary final figures for 1925 are not yet available. The Committee also plans to make a 1927 calendar which will be based on 1925 figures. In spite of the improvements in railroad earnings in 1925 over the preceding year, it appears—according to figures now available—that the distribution of expenses shown in the above calendar will not be altered by more than five or six days.

How to Improve Locomotive Efficiency

Paper Presented to New England Railroad Club Shows That Proper Counterbalance Reduces Track Stresses and Makes Greater Tractive Effort of Locomotives Possible

By H. H. LANNING, Mechanical Engineer, Atchison Topeka & Santa Fe Railway

In dealing with this subject I am compelled to confine my remarks to a description of the manner in which the mechanical department of the Atchison, Topeka & Santa Fe Railway under the leadership of John Purcell, assistant vice-president, has met a problem which is constantly before practically every American railroad, namely, how to build heavier and more powerful locomotives without overtaxing the strength of existing track and bridges. I should like to treat the subject in a broader manner, but am unable to do so because my contact with it has been limited to the work of investigation and development that has been done on the Santa Fe System.

I wish to make it clear in the beginning that the results I shall attempt to describe have been achieved through extensive and sustained co-operation among a large proportion of the personnel constituting the system mechanical staff, what has, however, refused persistently to let anybody drop the matter until his part of it has been done thoroughly and well.

Since this discussion is to be based on stresses produced by a locomotive in the rails over which it runs, it will be of interest and worthwhile to devote a few minutes to an explanation of the method and instruments used for measuring and recording rail stresses as they are produced by the moving locomotive.

The instrument used for the investigation on which this discussion is based is known as the stemmatograph. This instrument records the strain or change in length in the base of a rail that takes place within a gauge length of four inches. The record is made by the point of a needle upon a revolving disc of smoked glass. Under no load conditions, the needle is caused to describe a true circle on the disc, the circle being used for a datum line from which strains recorded may be measured later. Each strain is recorded on the revolving disc by a deviation from the true circle by the path described by the needle on the revolving disc. The extent of the deviation from the true circle indicates the magnitude of the strain, while its direction either inside or outside of the datum circle shows whether the stress which produced it was one of tension or compression. Separate records are made by each instrument of the stresses produced in the inside and outside edges of the base of the rail, thereby permitting determination of the direction, as well as the magnitude of the forces applied to the rail. The records thus produced are read under a microscope having a specially graduated micrometer eye-piece, by which the magnitude of the deviations may be read and readily translated into stresses in pounds per square inch, by means of a constant which takes into account the section of the rail, the modulus of elasticity of steel and other persistent factors. Data representing four separate runs are recorded usually on each disc, each run taking up one-fourth of the circumference of the record.

Several instruments (usually four or six) are used under each rail, and the discs of the entire installation on both rails are revolved simultaneously from the same driving mechanism. Instruments attached to the same rail are sometimes spaced the same as the wheels of the locomotives to be tested, this in order that simultaneous records may be made under each wheel of the locomotive. For other purposes, particularly in counterbalance tests, the instruments are spaced at some convenient fraction of a driver circumference in order that several records may be obtained from each wheel for the same run. Since each of the instruments carries two discs, each records data for four runs, and each run produces from twenty-two to thirty stress indications. The number of readings that must be taken for the proper reduction and analysis of data are enormous. The reduction of data collected in a single season by the special committees of the American Railway Engineering Association and the American Railway Association, to whom we are indebted for a large part of the basis stress data for this paper, is said to have required 470,000 individual stress readings.

The positions of the counterweights, when passing over the instrument, are determined by marking off the rails adjacent to the instruments into graduations of one foot each. A mark to indicate the center of the counterweight is placed either at the edge of the counterweight or on the tire so that the position of the counterweight can be determined by observing the points on the marked section of rail over which the mark on the wheel reaches its lowest position. In the later tests, the position of the counterweight was determined by photographing the wheel as the locomotive passed over the section of marked rail. A high grade camera is used for this purpose and has been found to be more accurate than personal observations, particularly at high speeds.

The Santa Fe has adopted four standard types of steam locomotives. These are for passenger service:

On level territory—A Pacific type locomotive having 73-in. driving wheels and a tractive power of 40,800 pounds. Length of rigid wheel base 13 ft. 8 in.

On Mountain territory—A Mountain type locomotive having 69-in. driving wheels and a tractive power of 56,800 pounds. Length of rigid wheel base 18 ft.

For freight service on level territory—A Mikado type locomotive having 63-in. driving wheels and tractive power of 63,000 pounds. Length of rigid wheel base 16 ft. 6 in.

On Mountain territory—A Santa Fe type locomotive having 63-in. driving wheels and a tractive power ranging from 75,700 to 81,500 pounds, depending upon the steam pressure carried in the boiler. Length of rigid wheel base 22 ft.

All of the four standard types of locomotive were designed originally to have uniform driver loads at the rail amounting to approximately 60,000 pounds for each pair of drivers. The Santa Fe type locomotive was equipped originally with plain or flangeless tires on the main or middle pair of driving wheels. All of the other drivers were flanged. All driving wheels of the Pacific, Mountain and Mikado types had flanged tires.

As a result of the study of track stresses produced by early examples of these locomotives, it was found possible to refine the designs in a manner permitting a considerable increase in the average driver load. This increased weight on drivers permitted a corresponding increase in tractive power, which was obtained by increasing the

boiler pressure, together with the application of improvements such as feed water heater, a new design of exhaust nozzle, improved draft appliances, table grates, and other features which are outside of the scope of this subject. I shall try, however, to explain how it was possible to increase the weight of the locomotive without overstressing existing track, thereby utilizing the additional power available from the various improvements above mentioned.

The investigation on which this discussion is based was made on locomotives of these types, most of it having been conducted in connection with Mountain and Santa Fe type locomotives which are used in the mountainous territory of New Mexico, Arizona and California.

All of the tests were conducted on rails weighing ninety pounds a yard.

Since locomotives of the types referred to exhibit certain characteristics with regard to track stresses on straight track and other characteristics on curved tracks the subject divides itself naturally into two sections, which have to do with the effects produced on straight and curved tracks respectively.

It is understood readily that a moving wheel carrying a load of vibrating machinery will produce, in the rail stresses that are different and more severe, from those that would be set up by the same wheel and load under purely static conditions. In the case of a railway track another cause for live load stresses is found in the fact that the earth supporting the ballast and ties under the rail is elastic and yields under the wheel loads of locomotives and cars. The result is that the rail is depressed slightly under each wheel and may be elevated slightly between wheels. This, in effect, produces a wave in the rail which precedes each moving wheel. The effects of this combination of conditions existing under a moving wheel, together with the effects of other conditions such as centrifugal forces produced by unbalanced weights in the wheels, constitute what are termed "speed effects." These effects are created in both straight and curved tracks, but are of greater importance in straight track, for the reason that locomotives usually move at higher speeds on straight track than they do on curves.

The investigation showed that stresses due to speed effects, exclusive of counterbalance, at forty to sixty miles an hour for the various locomotives tested, range from 15 per cent to 27 per cent of the stresses produced by the same wheels at five miles an hour. The stresses produced at five miles an hour are taken as a basis of comparison for the reason that the static weights of the wheels are often misleading because the boxes, equalizers, and spring rigging parts of a locomotive always move with a great deal of friction, and the values obtained by weighing individual wheels, even with the best scale that can be had for the purpose, may not show correctly the condition that would exist if there were no friction. The element of friction is considered to have been removed when the locomotive is in motion, even at very slow speeds, by reason of the fact that variations in track level keep the springs and equalizers in motion constantly, and the further fact that the values arrived at are obtained by averaging a very large number of readings. Increase of 15 to 27 per cent over the stresses produced at five miles an hour are considered moderate and allowable. However, it is interesting to notice that the length of unloaded rail between wheels has a direct bearing on rail stresses due to speed effects. The data show that the upward reaction of the rail between wheel contacts produces stresses that bear certain relations to the distance between the points at which the direct loads are applied to the rail. These indirect, or reactionary, stresses amount usually to about fifty per cent of the direct stresses produced by wheel loads, but may become larger if the wheel spacing is increased unduly. These stresses are of some importance in the case of a pair of trailer wheels heavily loaded as there is usually a considerable length of unloaded rail between the trailer and rear pair of drivers. It is desirable, therefore, to avoid excessive distance between wheels following each other along the same rail.

One of the locomotives used in the investigation was equipped with a four-wheel trailer truck, which had been applied to the engine in place of the standard two-wheel Hodges type trailer truck that was common to the other original locomotives. It was found that the four-wheel truck had the effect of reducing the reactionary stresses between wheels because the length of unloaded rail between the rear drivers and trailer was decreased. The four-wheel trailer truck had the further advantage of dividing between four wheels the load that would otherwise be carried on two.

It was found that, as a rule, uniform driving wheel loads at the rail gave satisfactory rail stresses on straight track. However, the importance of avoiding extreme loads on a single pair of trailer wheels was demonstrated clearly, and it was decided that this load should not exceed the average driver load.

Insufficient counterbalance, particularly in the main driving wheels, was found to be the cause of the most severe stresses produced in the rails of straight track. Counterbalance effects amounting to more than 100 per cent of the stresses produced at five miles an hour were observed in connection with one of the locomotives tested by the joint committee of the A. R. A. and A. R. E. A. It was found that none of the locomotives tested had sufficient counterweight in the main wheels to counteract properly the centrifugal forces produced at high speeds, by the weight of the rods and other parts carried on the main crankpins. This was true notwithstanding the fact that extra weights to counteract reciprocating forces had been placed in the counterweights of the main wheels, in addition to the weight required to balance the rotating parts according to the static method. This was found to be due to the fact that the centers of gravity of the counterweight and the weights on the main pin, do not revolve in the same vertical plane. It was shown that at high speeds the stresses under the main wheels were greater when the crankpin was down than when the counterweight was down.

The remedy for this condition was found to lie not only in making the greatest possible use of refinements in designs and materials for revolving and reciprocating parts, whereby maximum reduction of weight in these parts may be obtained, but it was found necessary also to keep the centers of gravity of these parts as close as possible to the planes in which the counterweights revolve. In the design of large locomotives having long main crankpins and heavy rods, it is desirable to make special provision for the differences in plane of the various weights to be considered. This may be done by increasing the weight of the counterbalance in the main wheel sufficiently to make up for the overhang of the main pin and rods. The desired effect may be accomplished also by cross-counterbalancing these overhanging weights by applying to the opposite main wheel a weight whose centrifugal moment is equal, and opposite, to the moment of the overhanging weights mentioned. The latter method has the advantage of accomplishing the desired results with a minimum increase in total weight. However, it is more complicated, and therefore more likely to be misunderstood when counterbalancing wheels in the shop.

The counterbalance of one of the Pacific type locomotives used in the investigation was corrected in accordance

with the plan mentioned first, that is, by adding to the regular counterweight of the main wheels. The additional weight required was arrived at experimentally, and when finally adjusted so as to eliminate stresses produced by counterbalance effects in the main wheels, it was found that the effect of the counterweight at crank radius was 1,914 pounds in each main wheel, as compared to 1,617 pounds which, according to the static method, was sufficient to balance the revolving weights plus an allowance of 287 pounds for a portion of the reciprocating weights in accordance with the 50 per cent counterbalance method.

Special Counterbalance

As a step in the development of a more satisfactory counterbalance for the heavy Santa Fe type locomotives, an engine of this type included in a recent order for new locomotives was equipped with a special arrangement of counterbalance. The main wheels of this locomotive were cross-counterbalanced to compensate for the differences in the plane of the rotating masses. The reciprocating weights of this locomotive are counterbalanced independently of the revolving weights, by the use of small weights applied at right angles to the counterweights in each driving wheel other than main. The small weights are applied to the wheels on the opposite side of the engine from the reciprocating parts whose weights they are intended to counterbalance. This locomotive, when tested, showed that the counterbalance effect of the main wheels had been eliminated practically while the counterbalance effects of the other wheels were quite low at all speeds. The engine has been in service nearly two years and has been found to possess very good riding qualities, as well as remarkably low track stress characteristics.

The subject of rail stresses produced by counterbalance is still under investigation.

It might be well, in connection with the counterbalance discussion, to refer to the desirability of checking the counterbalance of locomotive driving wheels as the engines pass through the shops for repairs. This is desirable particularly in the case of lead-filled counterbalance pockets. It is a common occurrence for lead-filling to become loose in the counterweight pockets of a locomotive driving wheel, and when once loosened the constant shifting of the lead in the pockets pulverizes it so finely that it escapes through any opening that may exist in the walls of the pocket. It happens frequently that evidence of loss of lead in this manner cannot be detected easily by external inspection of the wheels, hence the desirability of checking the counterbalance by the static method at each shopping of the locomotive. When filling counterbalance pockets with lead, extreme care should be exercised to insure the complete removal of all dirt, core, sand, etc., as material of this nature crumbles easily and is therefore conducive to loose counterbalance fillings. Lead applied to counterbalance pockets of driving wheels should be distributed equally on either side of the center line of the counterweight, and all spaces left in pockets partially filled with lead should be filled with cement, or other suitable material that will prevent the lead from shifting.

On superelevated curves of six degrees or more, it was found that speed effects produced by the Mountain, Mikado and Santa Fe type locomotives at all speeds below the safe maximum for the curve, were exceeded by stresses due to other effects that were found to be peculiar to curved tracks. Consequently speed effects are of relatively minor importance in the consideration of rail stresses produced on curved tracks.

Some very interesting data were obtained by running the Mountain and Santa Fe type locomotives into the ten degree curve of the test track, and then allowing them to come to rest without an application of brakes. Measurements were taken to determine the relative positions of the various wheels with respect to the rails. Measurements were taken also to determine the lateral deflections of the heads of the rails from no-load position, that were found under each wheel of the locomotive while standing on the curve. From this investigation it was found that a radius of the curve drawn at right angles to the longitudinal center line of the locomotive driving wheel base intersected the inside rail of the curve at, or close to, the point of contact under the next-to-rear driver. This statement is true of both the Mountain and Santa Fe types and is of particular interest for the reason that the pivot point or vertical axis, about which the locomotive turns in changing progressively its direction on the curve, is said to lie at, or near, the intersection of this radial line with the inner rail of the curve. With the Mountain type locomotive standing on the ten degree curve, the head of the outside rail was found to be sprung or deflected outward approximately 5/16 inch under the front driving wheel, and nearly ¼ inch under the trailer wheel. The inside rail was found to have been sprung or deflected outward or away from the center line of the track a full ½ inch under the third or next-to-rear pair of drivers. It was noted also that the flange of this wheel was not in contact with the rail. The rail deflections found in these tests were influenced to a certain extent by the proximity of rail joints to the points of maximum deflection, but are characteristic of the Mountain, Mikado and Santa Fe types when standing on or moving at slow speeds around ten degree superelevated curves.

The stresses at five miles an hour in the base of the inside rail of the curve under the next-to-rear driver of both the Santa Fe and Mountain type locomotives as built originally were found to be very high, ranging between 40,000 and 47,000 pounds a square inch for the Mountain locomotive and 50,000 to 55,000 pounds a square inch for the Santa Fe type. The stresses in the outside rail under these engines at the same speed were somewhat higher under the front drivers and trailer than under the remaining wheels of the locomotive, but these low speed stresses in the outside rail were not excessive in any case. A maximum low speed stress of 27,000 pounds a square inch was recorded in the outside rail under the first driver of the Santa Fe type, and 22,000 pounds a square inch in the same rail under the trailer of the Mountain type. As the speed increases, the stresses in the outer rail increase, while those in the inner rail decrease, the nearest approach to equalization of stresses being obtained at approximately the speed of superelevation. At speeds higher than the speed of superelevation, the stresses in the outside rail under the front truck, first driver and trailer, became quite high, the maximum stresses observed being nearly 50,000 pounds a square inch under the front driver of the Santa Fe type and 42,000 pounds a square inch under the trailer of the Mountain type locomotive.

The Santa Fe type locomotive equipped with the four-wheel trailer truck showed a considerable improvement over the two-wheel truck as regards rail stresses on curves. The stresses under the wheels of the four-wheel truck were quite moderate. The characteristic high stress at low speeds in the inside rail under the next-to-rear driver was somewhat lower with this engine than with the original test engines of this type which had two-wheel trucks. The stress at high speed (thirty-five miles an hour) in the outside rail under the front drivers of the engine with the four-wheel trailer was reduced to 30,000 pounds or a little more than half of the corresponding stress for the same wheel under the engine equipped with the two-wheel trailer

truck which was tested against it. The outside wheel of the front truck of the engine equipped with the four-wheel trailer truck produced a stress of 35,000 pounds a square inch in the outside rail at high speed, showing that the duty of this wheel in guiding the locomotive around the curve had been increased by the action of the four-wheel trailer truck.

The Mikado type locomotive exhibits on a ten degree curve approximately the same characteristics as the Mountain type locomotive, but the stresses produced are somewhat lower.

The Pacific type locomotive exhibited no very striking characteristics in either rail of the ten degree curve. The stresses produced in both rails of the curve being moderate at all speeds up to the maximum allowed on the curves.

Maximum Stresses on Curves

The maximum stresses in both the inner and outer rails of the ten degree curve are found to be the result of forces tending to deflect the rails outward and away from the center line of the track. The principal stress produced is therefore one of lateral bending. The test data proved with fair conclusiveness that friction between the tread of the wheel and the top of the rail, rather than direct flange pressure against the rail, is responsible principally for the high stresses recorded. In the case of the outer rail, the stresses recorded are due, obviously, to forces and reactions produced in guiding the locomotive around the curve. The reason for the high stress and deflection in the inner rail under the next-to-rear drivers of the Mountain and Santa Fe types is not clear entirely. The most acceptable explanation of this peculiarly high stress is that the point or vertical axis about which the locomotive rotates in changing progressively its direction on the curve, lies at, or near, the point of contact between this wheel and the rail, and a horizontal twisting effect is imparted therefore to the rail at this point. The nature of the deflection of the rail under this wheel as described previously tends to support this explanation. Further confirmation of this view and proof of the statement that friction, and not flange pressure, is responsible for the high stresses and deflection, is found in the fact that dampness or lubrication on the top face of the rail brings about marked deductions in the stresses. The tests indicate that the lubrication of driving wheel flanges, as well as the gauge faces of the rail, also tends to reduce rail stresses, but data is not available to show the value of this reduction in pounds per square inch.

It appears from the test data that any change of construction or adjustment of parts of a locomotive which affect the tracking of the different pairs of wheels or the position assumed by the rigid wheel base with respect to the rails, has the effect of changing this so-called pivot point, and, therefore, affects the rail stresses produced, particularly the characteristic slow-speed stress in the inside rail under the next-to-rear driver. It is interesting to notice in this connection that when a locomotive is moving backward around the ten degree curve a high stress in the inside rail, corresponding to that produced in the same rail by the next-to-rear driver when the locomotive is moving forward, appears under the No. 2 driving wheel which, when the locomotive is moving backward, becomes in effect the next-to-rear driver.

There are a number of features of locomotive construction which appear to have the effect of moving the so-called pivot point. These are:

Length of rigid wheel base.

Use of plain tires on one or more pairs of driving wheels.

Lateral play between flanges and rail, and between hubs and boxes.

Lateral flexibility provided for by hangers or rockers of trucks and driving boxes of the lateral motion type.

Length and location of attachments of radius bars of front and rear trucks.

The effects of differences in length of rigid wheel base are understood too commonly to need discussion.

As stated previously, the Santa Fe type locomotive, as built originally, was equipped with plain tires on the main or middle pair of driving wheels, and these locomotives developed in the inside rail of ten degree curve, under the next-to-rear drivers, stresses amounting to approximately 50,000 to 55,000 pounds a square inch. On account of the serious magnitude of this stress, a series of tests was made to determine the effects of using plain tires on other pairs and combination of driving wheels. On one of the test locomotives, the plain tires were shifted from the main or third pair of drivers to the fourth, or next-to-rear pair, the main wheels being equipped with flanged tires for this test. This change in location of the plain tires had the effect of transferring the high stress in the inside rail from the fourth driver to the main drivers and increased it to 65,000 pounds a square inch, which approximates the elastic limit of rail steel. Later tests were made with both the third and fourth pairs of drivers equipped with plain tires and a third test was made with plain tires on all except the front and rear drivers. The effect of both of these latter arrangements was to transfer the heavy stress in the inside rail of the ten degree curve to the rear driver with no reduction in the magnitude of the stress. The tests showed plainly that the use of flangeless tires has the effect of increasing, rather than decreasing, the stresses, produced by long wheelbase locomotives in the inside rail of superelevated curves.

Stresses with Flanged Tires on All Wheels

Following the tests made with different arrangements of flangeless tires, another test was made with the same engine equipped with flanged tires on all wheels. With this arrangement of tires, the slow speed stress in the inside rail under the fourth, or next-to-rear drivers, was still the predominating stress under the locomotive, but it had been reduced to 48,000 pounds a square inch, with no increase in the stresses produced by other wheels.

Since friction is shown to be the medium through which serious lateral bending stresses are imparted to the rails under heavy locomotives, it follows that the high stresses developed under certain wheels can be reduced by reducing the weights of these wheels and increasing the weights of other wheels, thereby equalizing all of the stresses under the locomotive. In line with this reasoning, tests were made with Mountain and Santa Fe type locomotives on which the equalizers had been changed to reduce the weights of the front and two rear pairs of drivers, the weight on the main and intermediate drivers being increased so as to retain the same total weight on driving wheels. By following this practice in changing equalization, the maximum stress in the inside rail of the ten degree curve was reduced ultimately to 33,000 pound a square inch for the heavy Santa Fe type locomotive as compared to 50,000 pounds a square inch for the same locomotive having equalizers arranged to produce uniform driver loads. Similar changes in the equalization of the Mountain type locomotive reduced the maximum stress in the inside rail of the ten degree curve under the third driver to 31,000 pounds a square inch, as compared with 43,000 pounds a square inch for the same type of engine with equalizers arranged so as to produce uniform driver loads.

The results obtained in these tests were so satisfactory that the following distributions of weights were recom-

mended for the Mountain, Mikado and Santa Fe type locomotives:

Mountain and Mikado Types

Leading truck approximately one-half average driver load for each pair of wheels.

First driver 24.6 per cent total weight on drivers.

Second driver 26.2 per cent total weight on drivers.

Third driver 24.6 per cent total weight on drivers.

Trailer, two-wheel type, not to exceed average load per pair of drivers.

Santa Fe Type

Front truck approximately one-half average driver load.

First driver 19 per cent total weight on drivers.

Second driver 21 per cent total weight on drivers.

Third driver 22 per cent total weight on drivers.

Fourth driver 19 per cent total weight on drivers.

Fifth driver 19 per cent total weight on drivers.

Trailer, two-wheel type, not to exceed the average load per pair of drivers.

The weight of the main drivers of Pacific type locomotives built recently has been increased somewhat over the weights of the front and rear drivers, but it has not been considered necessary to change the weight distribution of the older locomotives having uniform driver loads.

The test data developed in connection with the earlier standard Mountain and Santa Fe type locomotives showed that by using the weight distribution that gave best results in the test, improving the counterbalance of the driving wheels, as well as the design of trailer trucks, it would be possible to build new locomotives of these types with considerably heavier driver loads without stressing unduly existing tracks. Specifications for new locomotives of these types were therefore arranged to provide for the total weight on drivers to be increased, the distribution of weights being in accordance with the proportions developed in the test. Improvements in the design of the trailer truck that provided for greater freedom of lateral movement on curves were included also. These trucks were specified to be of the two-wheel type for the reason that the tests showed that this type of truck could be continued in use without overstressing the track. The latest Mountain type locomotives built by the Santa Fe weigh 246,300 pounds on drivers, as compared with 239,260 pounds on the drivers of the older engines of this type. Some new Santa Fe type locomotives built in 1924 weigh 317,760 pounds on drivers, as compared with 297,900 pounds, which was the weight on drivers of one of the locomotives that developed the highest rail stresses recorded in the tests. Tests made with recent Mountain and Santa Fe type locomotives show that notwithstanding the increased total weight on drivers, the maximum rail stresses developed on the ten degree curves are 32,000 pounds a square inch for the Mountain type and 36,000 pounds a square inch for the Santa Fe type. The reduction in maximum stresses, as compared with the original locomotives of these types which had uniform wheel loads of approximately 60,000 pounds an axle, amount to 20 per cent in the case of the Mountain type locomotive and 28 per cent for the Santa Fe type locomotive. Increased boiler pressure, together with the application of reinforcements and improvements, such as feed water heaters, additional sand domes, etc., that were made possible by the increased allowable weights have resulted in increased tractive power to the extent of 2,700 pounds, or 5 per cent for the Mountain type locomotive, and 5,800 pounds, or 8 per cent for the Santa Fe type.

The investigation also resulted in the development of a practical four-wheel trailer truck that may be applied in place of the usual two-wheel truck. While at present it has not been found necessary to utilize this type of truck, it seems probable that it will come into more general use with the constantly increasing demands for greater tractive power and utilization of poorer grades of fuel, which will, without doubt, necessitate larger and heavier fireboxes and grates.

While the results obtained so far from the study and application of track stress data are considered to have been well worth while, I feel that much remains to be done along the lines of designing or redesigning locomotives with the idea of minimizing their effects on the track. Practically every new development in locomotive design that affects weight, hauling capacity, length of wheel-base, or the tracking of any of the various pairs of wheels, has some effect either good or bad, on rail stresses. The margin of safety between the strength of ordinary rails and the stresses produced by the loads placed upon them is not large. A careful study of possible effects on the track, proved experimentally when possible, should therefore be made when improvements that are likely to increase track stresses are being considered for either old or new locomotives. Reduction of track stresses is important not only from the standpoint of safety and reduction of track maintenance, but also from the standpoint of track maintenance. Every stress produced in the rail has a counterpart in some part of the locomotive, and, as a general rule, it may be considered that a locomotive that is easy on the track will also be easy on itself.

Locomotives in Record Condition

Fewer locomotives were in need of repair on June 1 this year than at any time since the compilation of these records began in 1920, according to reports just filed by the railroads of this country with the Car Service Division of the American Railway Association.

The total number of locomotives in need of repair on June 1 was 9.266 or 14.7 per cent of the number on line. This was a decrease of 557 locomotives compared with the best previous record which was on October 1, 1923, and at which time there were 9,823 in need of repair or 15.3 per cent.

The total number in need of repair on June 1 this year was also a decrease of 715 compared with the number in need of repair on May 15, at which time there were 9,981 or 15.9 per cent. It also was a decrease of 1,636 locomotives compared with the number in need of repair on June 1, 1925, at which time there were 10,902 or 17.0 per cent.

Of the total number of locomotives in need of repair on June 1 this year, 5,055 or 8.0 per cent were in need of classified repairs, a decrease of 489 locomotives compared with May 15, while 4,211 locomotives or 6.7 per cent were in need of running repairs, a decrease of 226 within the same period.

Class I railroads on June 1 had 5,913 serviceable locomotives in storage, a decrease of 11 compared with the number on May 15.

The following table is a recapitulation of locomotives in need of repair, since the first of the year:

	Number	Per Cent
January 1	9,769	15.4
January 15	10,736	17.0
February 1	10,087	16.0
February 15	10,682	16.9
March 1	10,076	16.0
March 15	10,965	17.4
April 1	10,191	16.2
April 15	10,582	16.8
May 1	9,836	15.6
May 15	9,981	15.9
June 1	9,266	14.7

Report to Mechanical Division of the A. R. A.

Standardization of Water Columns

The sub-committee on the standardization of water columns for locomotives, of which G. H. Emerson, chief of Motive Power of the Baltimore & Ohio, was chairman reported as follows: The Committee, after giving careful consideration to this subject, make the following recommendations for future installations:

All water columns and water glasses must stand vertically.

Water column should be not less than 3 inches inside diameter and of sufficient length to accommodate length of water glass required for the operating conditions and to have a clear opening for top connections of not less than 1½ inches inside diameter and be connected to boiler with not less than 1½ inches outside diameter copper pipe, tapped into boiler on top center or in a location not farther to the side than 9 inches and not nearer than inside edge of back head seam.

Top spud connection standard in boiler to be not less than 1¼ inches inside diameter.

Bottom end of column, to provide for vertical range in location, should be supported and connected to boiler with heavy cross connection and spud with clear straightway bored port ¾ inch diameter, with cleaning plugs located opposite horizontal and vertical ports. Spud should be of forged steel or bronze of ample strength to carry the weight of column and attachments.

Bottom water column vertical connection to be not less than 1¼ inches inside diameter, preferably larger.

Back head of sloping type may be reinforced with open hearth steel bevel washer welded in place to provide horizontal applications of bottom spud.

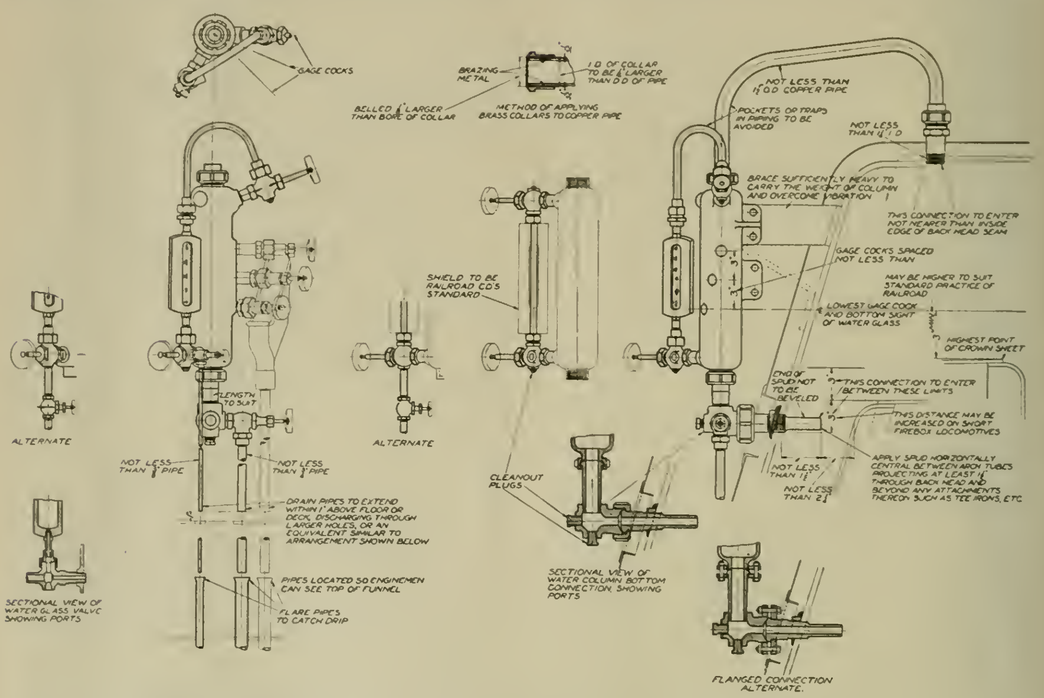
Bottom spud must not be located in radius or knuckle of back head flange or immediately above arch tube opening.

Inner end of the bottom spud must extend not less than 1½ inches through the back head and beyond any attachments thereon, such as tee, angle iron, boiler braces, etc., to avoid location within water eddy or pocket where water may dam up.

Inner end of spud must not extend to or be less than 2¼ inches from firebox door sheet and be located in a vertical range between 3 inches below and 3 inches above the back end of firebox crown sheet.

Water column, vertical location, must be at such a height that the lowest gage cock attached therein, and the lowest visible reading of water gage shall not be less than 3 inches above the highest part of the crown sheet and may be located higher, to suit the standard practice of any road.

Bottom connection of water column must be equipped with not less than ¾ inch drain pipe and valve (preferable one inch), which can be easily opened and closed by hand, so that the water column and connection may be frequently blown out. The drain pipes should be well braced and extend separately to within one inch of the cab floor or deck, and discharage the waste steam or water through a hole, slightly larger than the diameter of the pipe, or an equivalent arrangement whereby the leakage discharged through these pipes may be observed above the deck.



An Arrangement of Water Columns, and Piping That Meets Requirements Proposed by Committee of the A. R. A.

Water columns should be located well toward center of back of head of boiler to afford protection and to avoid violent fluctation of the water while rounding curves. Extension handles to be applied to gage cocks when necessary, so as to bring them within easy reach of the engineman.

Gage cocks must not be less than 1/4 inch inside diameter.

Top end of water column to be securely braced to back head with a brace sufficiently heavy to carry the weight of column and overcome vibration.

Water column to be equipped with one water glass and three gage cocks which will be spaced not less than 3 inches center to center vertically.

Lowest reading of water glass to be on line with center of lowest gage cock.

Water glass of Klinger or other Reflex type should have stems not less than 5/8 inch outside diameter and 3/8 inch inside diameter.

Tubular glass when used to be 5/8 inch outside diameter.

Top and bottom pipe connection to water column and water glass must be applied without gaskets.

Water glass steam pipe connection not less than 1/2 inch outside diameter preferably 5/8 inch outside diameter.

Water glass, Klinger or Reflex type, top and bottom valve connection to have a bore of 3/8 inch in diameter and bottom connection provided with outlet located opposite vertical port. When side outlet blowout valve connection is used a cleaning port must be located opposite the vertical port.

Water glass tubular type bore of top and bottom valve connections into water column must not be less than 1/4 inch and preferable 5/16 inch.

Water glass vision not less than 5 inches, preferably 8 inches, depending on operating conditions.

Tubular type water glass when used must be equipped with a removable safety shield which will prevent glass from flying in case of breakage.

Water glass must be so located and maintained as to be quickly observable by engineman.

Water glass must be equipped with bottom blowout valve and pipe not less than 3/8 inch in diameter. When side outlet blowout valve and pipe connection is used a cleaning port must be located opposite the vertical port.

Steam pipes to be applied without sharp bends or pockets and provided with ball joint connections and belled at least 1/8 inches in diameter at end in bracing collar.

An application that meets these requirements is shown in the accompanying illustration.

The Committee recommends that these specifications and drawings be submitted to letter ballot for adoption as recommended practice for new construction and renewals.

Formula for Calculating Tractive Effort of Three-Cylinder Locomotives

The sub-committee appointed to develop a formula for calculating the tractive effort of three-cylinder locomotives and of which H. A. Hoke, assistant mechanical engineer of the Pennsylvania was chairman, reported as follows:

Within the past few years quite a number of three-cylinder simple locomotives have been built and no doubt the number of this type of locomotive will increase. It is evident, therefore, that a standard method of calculating the tractive power of such a locomotive should be established.

Assuming that the steam pipes and valves are of the same capacity, the power developed in cylinder of same size operating under the same steam pressure and valve condition will be the same irrespective of the number of cylinders with which the locomotive is equipped. Therefore, the formula for the three-cylinder simple locomotive must be based on the same principle as the formula for the two-cylinder locomotive taking into account the number and size of the cylinders.

Tractive Power Three-Cylinder Simple Locomotive

$$T = \frac{KPC^2S}{D} + \frac{KPC^2S}{2D}$$

When K=Constant as given in table.

P=Boiler Pressure in pounds per square inch.
C=Diameter of outside cylinders in inches.
C^1=Diameter of inside of cylinders in inches.
S=Stroke of outside cylinders in inches.
S^1=Stroke of inside cylinder in inches.
D=Diameter of driving wheels in inches.
T=Tractive power in pounds.

VALUES OF CONSTANT K

Main Valve Maximum Cutoff	Without Auxiliary Ports	With Auxiliary Ports With 80% Minimum Cutoff
90	.85	
80	.80	.80
70	.74	.78
60	.68	.77
50	.60	.75

Locomotive Developments—1925-1926

The sub-committee on Locomotive Developments submitted what may be termed a progress report on the following subjects reported on last year:

(1) High pressure and water tube boilers.
(2) Oil-electric or Diesel locomotives.
(3) The 3-cylinder locomotive.
(4) Manual operation by back pressure and effective pressure methods.

While we are not in a position to offer conclusive findings in connection with the first three subjects mentioned, we submit that the experience of the past year has helped to eliminate many troubles and develop valuable information.

In regard to item No. 4, "Manual operation by back pressure and effective pressure methods," we particularly point to the fact that this method constitutes the first attempt to give the locomotive engineer an idea of the actual results of throttle and reverse lever position with consequent fuel saving at a very low initial expenditure.

Higher Boiler Pressure and Water Tube Boilers

One of the most significant developments during the past year is the use of pressures ranging from 250 pounds to 350 pounds in various types of locomotive boilers. Theer are a large number of locomotive boilers of conventional design in service carrying pressures of 250 pounds—the most notable application being the Pennsylvania Railroad's 11s.

The first important departure from the conventional type at this pressure is the McClellon water tube boiler of the New Haven, on which we are now able to submit a report of road tests. As an example of the use of higher pressure—350 pounds—we submit a brief report on Delaware & Hudson Horatio Allen now in regular freight service and also mention the building by the Baldwin Locomotive Works of a 3-cylinder compound locomotive having a Brotan type water tube boiler carrying 350 pounds pressure. Test data covering this boiler is not

available at the time of writing this report but may be submitted in time for discussion at the convention.

While the service tests of high pressure boilers are not yet conclusive we submit that the general trend of design at least points to the use of the highest pressure possible with single expansion which up to the present has been 250 pounds.

McClellon Water Tube Boiler

In the report of 1925 reference was made to the McClellon water tube firebox developed on the New York, New Haven & Hartford Railroad in 1916. A 250-pound pressure boiler with this type firebox was built in the latter part of 1924, placed in regular road service and subjected to extensive tests in comparison with a standard engine in 1925.

The McClellon equipped locomotive was built to practically the same dimensions and characteristics of the conventional engine, except for the firebox and the increased boiler pressure. This permitted elimination of as many variables as possible and insured tests and performance being on a comparable basis. Values of grate area, heating surface, superheater surface, cylinder sizes, driving wheel sizes, etc., were the same in each locomotive.

A complete report of the tests referred to in the committee's report appeared in the February, 1926, issue of Railway and Locomotive Engineering.

Report of the 350 Lb. Pressure—Gross Compound Locomotive Horatio Allen

This engine has now operated through two winters, with repeated temperatures as low as fifteen (15) below zero, and through heavy snows. No trouble of moment has been experienced with the boiler and the limited amount had is localized in some seven or eight tubes connecting the two drums, and these of the inner row. The basic reason therefore has been conclusively developed and the necessary revision in design, to meet the same, provided.

For the past six months, in order that the entire operating personnel of the Division become fully conversant with the handling of this type of power, this engine has been in the pool. Due to the coal strike, freight movement has been materially reduced, but in a general way the major portion of the crews have handled the engine, consequently we have had the opportunity of gathering experience under the most adverse operating conditions.

As an outgrowth, specifications have been prepared covering a second engine, this to be a forerunner of others, after a limited period of service, to insure changes made have been those of advancement. In the main they are:

First—Increase in operating pressure from 350 to 400 pounds.

Second—Change from Duplex to Single Throttle.

Third—Better distribution of weight through the locomotive and a reduction of weight in casting designs.

Fourth—Five (5) instead of six (6) rows of tubes between the two drums, and these to be of the one diameter, 2½ inches.

Fifth—Elimination of desaturator.

Sixth—Increase of superheat to 700 plus degrees total temperature.

The aforesaid, much more clearly than words, sums our experience.

During the past year, no trouble has been experienced either with cylinder or rod packing.

The trouble mentioned at the last Convention, had with the pound in the main boxes, has been solved. There is no evidence of results of quarter-slip, question raised at last meeting, but when engine is shopped, which is expected will be necessary for tire turning before Convention, very careful observations will be made thereof and report made later.

Three Cylinder Locomotive

In last year's report on the three cylinder locomotive, reference was made to two main features:

First: The performance and resulting economies.

Secondly: The necessity of an extended test period to determine what maintenance conditions would be experienced.

Up to the present time the American Locomotive Company have built sixty-two three cylinder locomotives; 20 fast passenger, 32 freight, 10 heavy switches.

The builder's guaranteed claims for the three cylinder locomotive are:

(a) 15 per cent more hauling power than a two cylinder locomotive of equal weight on drivers.

(b) 15 per cent fuel economy in performing the same work as a two cylinder locomotive.

(c) A possible increase in value of the boiler capacity corresponding to (b) or in other words, a boiler capacity of 85 per cent being sufficient where a capacity of 100 per cent is necessary for the two cylinder.

Four railroads which have tested the three cylinder locomotive have placed repeat orders.

With regard to the maintenance features, a certain measure of trouble has been experienced with two parts:

(1) The back end of inside connecting rod.

(2) The cranked axle.

Many different designs of back end of connecting rods have been tried with varying success, but it is now felt that a design has been developed which will meet all service conditions either in slow or high speed work.

To date one cranked axle has failed but the builders claim that a careful investigation of results both in America and in England and Germany does not indicate that there will be serious difficulty in perfecting a design to meet the most difficult operating conditions.

We feel that before leaving the consideration of this development we should report that the past year's experience has done much to remove obstacles from the general use of the three cylinder locomotive and we suggest that this design is of vital interest to any railroad with exacting conditions and relatively low permissible axle loads.

Manual Operation by Back Pressure and Effective Pressure Method

Perhaps one of the most effective movements to improve fuel performance has been instituted during the past two years by certain railroads through the use of gauges indicating back pressure and initial or effective pressure to the engineer. It may appear at first sight that such indications will not mean much to the average engineer, but experience is indicating that on those roads where these devices are in operation there is a markd improvement in fuel performance, in some cases exceeding the results from the much more expensive devices which have become almost universal in application to new locomotives.

It must be appreciated that through the entire era of locomotive development no certain indication has been provided to the engineer to show him just what is the result of reverse lever and throttle position. As a result it appeared to some that eventually this control would have to be automatic in order to get the best results. Without in any way criticizing the use of a straight automatic cut-off control, is it not reasonable to endeavor to secure the best possible operating results by manual control through giving the engineer a direct indication as to what back pressure he is operating with? The direct result should be increased attention to the cut-off so as

to reduce the back pressure to the absolute minimum and thus increase the effective pressure.

To meet these requirements certain roads have applied back pressure gauges in the cab and pipes to the cylinders; others are testing out and have applied a later development—a gauge which indicates on the same dial the steam pipe pressure, the back pressure, and the resultant effective pressure. Without claiming that this indication can be as accurate as may be obtained by indicator diagram in a steam test we maintain that it is a practical indication to the engineer as to what he is doing and how he may obtain the best results, and we wish to submit that reports indicate increased fuel economies on modern power as the direct result of an application which will cost less than $100.00 per locomotive.

As an evidence of what is being accomplished we submit the following extract from a report of member railroad having several hundred locomotives fitted with gauges showing back pressure and steam pipe pressure and the effect it has had in fuel economy.

"By certain tests that we put on our engineers from time to time, we estimate that the back pressure gauges are conservatively saving us ten (10) per cent of our locomotive fuel."

Report on Couplers and Draft Gears

The committee of which R. L. Kleine, assistant chief of motive power of the Pennsylcania, was chairman presented statistical tables showing the failures of standard D couplers in service.

The "D" coupler head was adopted as standard in 1916 and the 6 x 8 inch shank in 1918, and up to January 1, 1926, a total of 2,896,770 "D" couplers have been shipped by the manufacturers, including both the 6 x 8 and 5 x 7 inch shanks.

Information is not available to permit showing separately the number of "D" couplers of different shank sizes, but the total number shipped by years is as follows:

Prior to 1918	41,929
1918	148,777
1919	92,276
1920	309,541
1921	199,954
1922	472,866
1923	631,793
1924	464,989
1925	534,945
Total	2,896,770

In order to obtain comprehensive information as to how this complete design is standing up in service, the eight railroads represented on the Committee on Couplers and Draft Gears arranged for a special examination and report covering a period of six months during 1925 of all standard D couplers, including both the 6 x 8 inch and 5 x 7 inch shank sizes that, on account of failure of any kind, were removed from service.

The freight car ownership of the railroads in question is 38 per cent of the total of the country, and, as roads operating in mountainous as well as in level sections are included, the figures may be considered as representative. Tabulations have been prepared and are submitted herewith in such form as to clearly show not only the number and location of the failures, but the year couplers were cast and under certain groupings the capacity of the car from which the defective coupler was removed.

An analysis of these exhibits is as follows:

Failures of 5x7 ins. A.R.A. Standard D Couplers

There were 466 failures of heads and 1,106 failures of shanks on a total of 1,534 couplers removed. Of this number 715 were unreclaimable and had to be scrapped. The remaining 819, practically all of which had bent shanks, were repaired and returned to service.

Failures of 6x8 ins. A.R.A. Standard D Couplers

There were 805 failures of heads and 141 failures of shanks on a total of 906 couplers removed. Of this number 884 were unreclaimable. The remaining 22, principally having bent shanks, were reclaimable.

It will be observed that of the 5 x 7 inch shank couplers 1,106, or 72.1 per cent, had shank failures while for the 6 x 8 inch size there were but 141 shank failures, or 15.5 per cent. As the heads of the two couplers are identical these figures clearly show the greater strength of the 6 x 8 inch shank.

The tabulations show a total for the six months period of 1,599 type D couplers that had to be scrapped on the eight roads reporting.

In order to determine to what extent coupler shanks are shortening or lengthening in service, the shanks of all defective couplers were measured where possible to determine the correct length, and their dimensions are given. It will be seen that while both shortening and lengthening is taking place, the shortening as would be expected predominating, but is not serious, although it is highly desirable to limit this to a minimum.

The standard tolerances permit one-eighth inch variation above or below the length of 21¼ inches, which should be taken into account when considering the figures given in the tabulation.

Failure of A.R.A. Standard D Coupler Heads

All breakages of D coupler heads, regardless as to the size of shank, are shown on this sheet, which is a tabulation of defects, the number of defective heads being given on the last line.

The total of 1,453 defects found in 1,271 heads may be grouped as follows:

Guard Arm	247	or 17.0%
Face of Coupler	696	or 47.9%
Side Wall Knuckle Tail Cavity	370	or 25.4%
All other locations	140	or 9.7%
		100%

During the latter part of 1917 a change was made in the design of the knuckle tail cavity so as to strengthen that part and again in 1925 a further slight modification was approved. Failures of this portion of the head are becoming much less frequent, as of the couplers cast in 1917 that failed, 86 or 48.5 per cent of the failures were in this location, while in 1923 the figure dropped to 23 or 14.7 per cent, and for 1924 was 11 or 14.6 per cent.

Failure of 5x7 ins. A.R.A. Standard D Coupler Shanks

There were 1,136 failures reported in 1,106 shanks. Of these 902, or 79.4 per cent, were bent shanks, the great majority of which were reclaimable. The remaining 234 failures were cracked or broken shanks, 89 or 7.8 per cent of the total being at the juncture of the head and the shank and 126 or 11.1 per cent through the key slot. Miscellaneous locations 19 or 1.7 per cent.

Failure of 6x8 ins. A.R.A. Standard D Coupler Shanks

146 failures reported in 141 shanks. Of these defects 49 or 33.6 per cent were bent shanks, the remaining 97 failures being cracks or breaks located as follows:

Juncture of head and shank	73 or	50.0%
Key Slot	19 or	13.0%
Miscellaneous locations	5 or	3.4%

Failure of A.R.A. Standard D Coupler Parts

The only detail part of which any considerable number was reported defective was the Top Lock Lift. These were largely of the old design removed on account of wear from contact with the anti-creep ledge and replaced with the present No. 2 Top Lock Lifter.

Copies of Exhibits A to E, inclusive, have been furnished to the Mechanical Committee of the Coupler Manufacturers Association for their information and consideration in connection with the study of coupler design.

In the 1913 report of the Committee on Coupler and Draft Equipment 5,698 steel coupler bodies removed from cars were reported as scrapped during the month of March, 1912, on the former Pennsylvania Railroad Lines East. During the six months period of 1925 covered by our study of failures of standard D couplers, there was an average of 73 failures a month of standard D couplers on the entire Pennsylvania Railroad.

In the former instance the Pennsylvania Railroad Lines East owned 159,910 freight cars, while in 1925 the number owned by the Pennsylvania Railroad that were equipped with standard D couplers was 116,970. On the basis of these figures there was a failure of one former M. C. B. type coupler per 28.1 car months, whereas for the standard D coupler there was but one failure per 1,602 car months, which is indicative of the greatly increased strength of the standard D coupler compared with the former M. C. B. types.

It should be borne in mind in the case of the standard D coupler that while some have been in service since 1917 the average length of time in service is not yet sufficient to develop their ultimate service life.

Draft Gear Drop Test Machine

The members will be interested in knowing that order has been placed with the Tinius-Olsen Testing Machine Company of Philadelphia, Pa., for the draft gear drop test machine, delivery being called for by November 1, 1926, and that the detail drawings are well under way.

This drop test machine will be provided with two falling weights or tops, the larger weighing 27,000 pounds and the smaller 9,000 pounds. The design will be such that the weights may be readily exchanged without dismantling the main columns.

It has been decided by the General Committee that the drop test machine will be located at Purdue University and negotiations to that end are in progress. The method of conducting tests of draft gears is being worked out and will be submitted to the various manufacturers of draft gears in order that the Committee may receive the benefit of their suggestions or criticisms.

Committee Report on Locomotive and Car Lighting

The locomotive and car lighting committee of which W. E. Dunham, Superintendent, Car Department, Chicago and Northwestern Railway, was chairman, reported as follows: After considerable correspondence and conference with the proper committee of the operating division in regard to Electric Lights for Classification Lamps and Markers on Locomotives and Tenders, cuts were prepared and submitted to that committee for their handling in connection with revision of the standard code of train rules.

No radical change from present practices is contemplated in regards to the Axle Belt Drive. Opinion appears to be general that a wide faced axle pulley is desirable, but the most serviceable width all factors considered has not been proved. It is to be hoped that eventually the pulley design can be improved to simplify its application. Reduction in weight is desirable, as is also a more satisfactory bushing. There is an evident desire for pulley mounted centrally on the axle with a single bushing, the face to be as wide as can be obtained consistent with the clearances and the single bushing support.

Nominations Committees Report

The nominations committees of which F. W. Brazier, Assistant to General Superintendent of Rolling Stock, New York Central Railroad, was chairman recommended the election for the year ending June, 1927, L. K. Sillcox, General Superintendent of Motive Power, Chicago, Milwaukee and St. Paul Railway, for chairman, and G. E. Smart, Chief of Car Equipment, Canadian National Railway, for Vice-Chairman.

The term of seven members of the general committee expired in June, the committee nominated the following to serve until June, 1928, as members of the general committee: C. E. Chambers, Superintendent of Motive Power and Equipment, of the Central Railroad of New Jersey; C. F. Giles, Superintendent of Machinery Louisville and Nashville Railroad; E. B. Hall, Superintendent of the Motive Power, Chicago and Northwestern Railway; A. Kearney, Superintendent of Motive Power, Norfolk & Western Railway; J. E. O'Brien, Chief of Motive Power and Equipment, Seaboard Air Line Railway; John Purcell, Assistant to Vice-President, Atchison, Topeka and Santa Fe Railway; J. T. Wallis, Chief of Motive Power, Pennsylvania Railroad.

George Little Fowler

It is with deep sorrow that we announce the death of George L. Fowler, consulting mechanical engineer, a writer and editor of eminent literary and scientific attainments and a member of the staff of RAILWAY AND LOCOMOTIVE ENGINEERING for the past eight years. Following an operation at the Brooklyn Hospital, Brooklyn, N. Y., he died July 2, 1926.

Mr. Fowler was born at Cherry Valley, N. Y., August 9, 1855, and was the son of Jonathan A. and Eliza O. (Little) Fowler. Following his graduation from Amherst College in 1877, he entered the shops of the Miltimore Car Axle Company at Arlington, Vt., where he remained three years, becoming foreman of the shops. He then entered the employ of the New York Central as draftsman in the mechanical department, doing both car and locomotive work. He then became chief draftsman of the Industrial Works, Bay City, Mich., manufacturers of excavators and traveling cranes. Later he was draftsman in the car and locomotive department of the Flint & Pere Marquette Railroad and was promoted to assistant master mechanic at East Saginaw, Mich. At this place he entered the employ of A. F. Bartlett Co., manufacturers of sawmill machinery and steam engines, as superintendent. He then came to New York, and after doing some editorial work went as superintendent of the Peckham Manufacturing Company at Kingston, N. Y., and afterwards became consulting engineer of the firm. Mr. Fowler then opened an office in New York as a consulting engineer and engaged in this work for the past thirty years, specializing in research work in the field of locomotive design, construction and operation. Among his clients were the Canadian Pacific, New York Central, New York, Ontario & Western, Pennsylvania, Erie, Long Island, Baltimore & Ohio, Big Four, Brooklyn Rapid Transit, Philadelphia Rapid Transit, as well as many prominent railway supply and equipment companies and State Railway Commissions.

Early in his career Mr. Fowler entered the field of railroad literature. In 1887 he began contributing to the pages of the *Railroad Gazette*, of which the late M. N. Forney was then editor. Later he became associate editor of that publication and the *Jour-*

nal of Railway Appliances. He was a contributing editor of the *Railroad Age Gazette* and the *Railway Age* almost continuously until 1919, when he joined the staff of RAILWAY AND LOCOMOTIVE ENGINEERING. Mr. Fowler was the author of the "Locomotive Dictionary," "The Car Wheel," "Locomotive Breakdowns Emergencies and Their Remedies," and the revision of "Forney's Catechism of the Locomotive," and compiled the indexes of the Proceedings of the American Railway Master Mechanics' Association and the Master Car Builders' Association.

He was a prominent member of the American Society of Mechanical Engineers and the American Electric Railway Association, serving on many of the important committees of the societies during the past twenty-five years.

It is not possible, nor is it necessary to here record his many notable achievements in his chosen profession. Some particular achievements of his original work were the investigations regarding the qualities of steels used in steel tires and solid steel wheels, and the stresses on car wheels. He made the first investigation in the world on the lateral stresses imposed on car and locomotive wheels while in service, and the only investigation up to the present regarding the lateral trust of the individual wheels of moving cars and trains. The result, as embodied in "The Car Wheel" have been largely instrumental in the abandonment of the cast iron wheel for higher capacity cars. He made the investigations that resulted in cutting down of the mileage allowance of switching locomotives from 6 to 3 miles per hour. He conducted the investigations for the establishment of the laws of rolling resistances and the gyroscopic action of the motors on electric locomotives, etc.

Mr. Fowler was a keen and liberal contributor of writings, lectures and discussions to the scientific, railroad and engineering organizations. In the pages of the Proceedings of such associations the memory of his record will long endure.

Mr. Fowler's personal characteristics were varied and strongly marked. Punctuality was his keynote. Honesty of purpose, his wonderful capacity for work and his love of it were outstanding qualities; his store of knowledge not only engineering and professional, but general was surprising; in all his activities he was decisive, brief and positive. In reviewing the record of this eminently useful life, one cannot be but impressed by the causes of its success. His ideals of education were high; nothing short of the best satisfied him. Of gentle disposition, the experience of life had developed in him extraordinary beauty of temperament and character. In the example of his earnestness of purpose, unceasing industry, love for his profession and for all that accompanies it lies the richest legacy he has left us.

In 1883 he was married to Harriet F. Goldie at Saginaw, Mich. Her death occurred several years ago.

Mr. Fowler is survived by a sister, Miss Alice L. Fowler, of Brooklyn, N. Y. He was interred at Cherry Valley, near his birthplace and former home, July 6, 1926.

His loss, though widely felt in railroad circles, is keenly felt by those who were associated with him in business. His spirit was illuminating and encouraging. He was a man of broad culture, a kind and gentle personality, and was honored and respected by all who knew him best. He was a keen critic, a scholarly and accomplished editor, a delightful companion and a courteous and kindly gentleman.

Notes on Domestic Railroads

Locomotives

The Akron Canton & Youngstown Railway has ordered 2 locomotives from the Lima Locomotive Works.

The Chicago & North Western Railway has ordered one 60-ton oil-electric locomotive from the Ingersoll-Rand, General Electric, and the American Locomotive companies.

The Minneapolis, St. Paul & Sault Ste. Marie Railway is inquiring for 12 locomotives.

The Illinois Central Railroad has ordered 50 2-8-4 freight locomotives from the Lima Locomotive Works.

The Vancouver Harbor Commission is inquiring for 2 switcher type locomotives.

The Atchison, Topeka & Santa Fe Railway has ordered 10 Santa Fe type and 15 Mikado type locomotives from the Baldwin Locomotive Works.

The Chicago, St. Paul, Minneapolis & Omaha Railway has ordered 8 Mikado type locomotives from the American Locomotive Company.

The Chicago, Indianapolis & Louisville Railroad has ordered 6 Mikado type locomotives from the American Locomotive Works.

The Atchison, Topeka & Santa Fe Railway is inquiring for 40 locomotive tenders of 15,000 gallons capacity.

The Alton & Southern Railroad has ordered one three-cylinder switcher type locomotive from the American Locomotive Company.

The city of St. Louis has ordered one four-wheel switcher type locomotive from the Baldwin Locomotive Works.

The Waukegan Generating Company has ordered one six-wheel switcher type locomotive from the Baldwin Locomotive Works.

The Louisville & Nashville Railroad has purchased 24 Mikado type and 8 Mountain type locomotives from the American Locomotive Company.

The Pennsylvania Railroad has ordered the shops at Altoona to build 60 switching type locomotives.

The Union Terminal Company has ordered one six-wheel switcher type locomotive from the Baldwin Locomotive Works.

The Newburgh South Shore Railway has ordered 2 six-wheel switcher type locomotives from the Baldwin Locomotive Works.

The Toledo, Angola & Western Railway has ordered one six-wheel switcher type locomotive from the American Locomotive Company.

The Atchison, Topeka & Santa Fe Railway has ordered 15 Mikado type and 10 Santa Fe type locomotives from the Baldwin Locomotive Works.

The Los Angeles Junction Railway has ordered one six-wheel switcher type locomotive from the American Locomotive Company.

The New York Central Railroad is considering the buying of 20 4-6-4 type locomotives.

The Al Pacifico Costa Rica has ordered 2 Consolidation type locomotives from the Baldwin Locomotive Works.

The Delaware & Hudson Company contemplates building 6 locomotives in its own shops.

The Chicago, Indianapolis & Louisville Railway has ordered 6 Mikado type locomotives from the American Locomotive Company.

The Inland Steel Company has ordered one 60-ton oil-electric locomotive from the Ingersoll-Rand, General Electric and American Locomotive companies.

The Royal State Railways of Siam have ordered 8 Pacific type three-cylinder locomotives from the Baldwin Locomotive Works.

Passenger Cars

The Lehigh Valley Railroad has ordered 4, 70 ft. double power gas electric cars from the J. G. Brill Company, Philadelphia, Pa.

The Seaboard Air Line Railway is inquiring for 40 express cars.

The Pennsylvania Railroad will build in its shops at Altoona 24 70 ft. all steel dining cars.

The Delaware, Lackawanna & Western Railroad has ordered 2 passenger-mail cars from the American Car & Foundry Company.

The Southern Pacific Company has ordered 11 steel diner cars from the Pullman Company.

The New York, Westchester & Boston Railroad has purchased 10 motor passenger cars from the Pressed Steel Car Company.

The Louisville & Nashville Railroad has ordered 15 combination mail baggage cars from the American Car & Foundry Company, also 10 baggage cars from the Pressed Steel Car Company.

The Seaboard Air Line Railway has ordered 20 passenger coaches from the American Car & Foundry Company.

The Great Northern Railway has ordered 5 gas electric motor cars from the Electro Motive Company.

The Lehigh Valley Railroad has ordered 4 dual power plant gas electric motor cars from the Electro Motive Company.

The Baltimore & Ohio Railroad has ordered 5 all passenger gas electric motor cars from the Electro Motive Company.

The Nashville, Chattanooga & St. Louis Motor Company has ordered 3 type Z buses and 2 type Z trucks from the Yellow Coach Manufacturing Company, Chicago, Ill.

The Temiskaming & Northern Ontario Railway has ordered 2 passenger and baggage gas electric cars from the Ottade Car Company.

The Seaboard Air Line Railway has ordered 32 60 ft. express cars from the American Car & Foundry Company.

The St. Louis-San Francisco Railway has ordered 4 60 ft. gas electric cars from the J. G. Brill and Westinghouse Electric Manufacturing Company.

The Union Pacific Railroad has ordered 10 70 ft. passenger-baggage gas electric cars from the Electro Motive Company.

The Wheeling & Lake Erie Railway has ordered 2 60 ft. passenger-mail and one 60 ft. passenger-baggage gas electric cars from the J. G. Brill Company, Philadelphia, Pa.

The Richmond Fredericksburg & Potomac Railroad is inquiring for one dining car.

The Erie Railroad has ordered 15 all steel passenger coaches from the Standard Steel Car Company.

The Paulista Railway of Brazil is inquiring through the car builders for 30 passenger cars.

Freight Cars

The Baltimore & Ohio Railroad has ordered 500 box cars from the Bethlehem Steel Company, also 500 from the Standard Steel Car Company.

The Wabash Railway is inquiring for 40 steel underframe cabooses.

The Tennessee Central Railroad has ordered 100 steel hopper cars, 100 drop bottom gondola cars, 25 flat cars and 25 stock cars from the Pressed Steel Car Company.

The Chesapeake & Ohio Railway is preparing specifications for 500 gondola bodies.

The Northern American Car Corporation has ordered 300 all steel 8,000-gallon tank cars from the Bethlehem Steel Company.

The United States Cast Iron Pipe Company is inquiring for 10 60-ton gondola cars.

The Northern Redwood Lumber Company has ordered 50 40-ton flat cars from the Pacific Car & Foundry Company.

The Chicago, Rock Island & Pacific Railway has ordered 200 steel underframes from the Bettendorf Company.

The Boston & Maine Railroad has ordered 6 air-operated dump cars from the Clark Car Company.

The Fruit Growers Express has ordered 400 steel underframes from the Ryan Car Company.

The Canadian National Railways has ordered 30 air dump cars from the National Steel Car Company.

The Great Northern Railway is inquiring for 3,200 steel underframes.

The Champlin Refining Company, Enid, Okla., has ordered 5 tank cars from the National Steel Car Company.

The Central Railroad of New Jersey has ordered 400 box cars from the Bethlehem Steel Company, 400 from the Standard Steel Car Company and 200 from the American Car & Foundry Company.

The Chicago, Burlington & Quincy Railroad is inquiring for 300 flat car underframes.

The Delaware, Lackawanna & Western Railroad has ordered 400 70-ton steel coal cars and 300 box cars from the American Car & Foundry Company, also 200 box cars from the Magor Car Company.

The Carnegie Steel Company has ordered 18 dump cars from the Clark Car Company.

The Michigan Alkali Company has ordered 30 air dump cars from the Western Wheel & Scraper Company.

The Norfolk & Western Railway will build in its own shops 250 flat cars.

The Great Northern Railway has ordered 20 underframes from the Siems Stembel Company.

The Chicago Short Line Railway is inquiring for 20 gondola cars.

The Chicago & North Western Railway has ordered 500 stock car bodies from the Illinois Car & Manufacturing Company and 25 caboose underframes from the Bettendorf Company.

The National Tube Company has ordered 25 gondola car bodies from the Pressed Steel Car Company.

The Crucible Steel Company is inquiring for 6 flat cars of 75 tons capacity.

The Calumet & Hecla Copper Company has ordered 5 ore cars of 50 tons capacity from the Pressed Steel Car Company.

The Kendall Refining Company has ordered one tank car of 10,000-gallon capacity from the General American Tank Car Company.

Buildings and Structures

The Maine Central Railroad has awarded a contract for the construction of an enginehouse and storage unit at Lewiston, Me.

The Delaware, Lackawanna & Western Railroad is completing the construction of a new shop for light freight car repairs at its East Buffalo shops.

The Chicago, Rock Island & Pacific Railroad will build a one-story shop building at Burr Oak, Ill. The building will be 62 by 120 feet.

The Central of Georgia Railway has completed plans for a new 19-stall enginehouse with repair facilities at Savannah, Ga., to cost approximately $100,000 with equipment.

The New York, New Haven & Hartford Railroad has awarded a contract for the construction of a machine shop at East Hartford, Conn.

The Atchison, Topeka & Santa Fe Railway has under construction a rail and frog shop building at Newton, Kan., to cost approximately $165,000. Additions are being made to the car shop at Ottawa, Kan., to cost approximately $100,000.

The New York, New Haven & Hartford Railroad has asked bids for a one-story locomotive repair shop at Readville, Mass.

The Wabash Railway has awarded a contract to the Foundation Company for the building of a locomotive repair shop at Decatur, Ill., to cost approximately $1,000,000.

The Chicago & North Western Railway is reported to be planning the construction of a new enginehouse with shop facilities at Jewell, Iowa, to cost approximately $40,000.

The Philadelphia & Reading Railway plans the construction of a new enginehouse with shop facilities near Trenton, N. J., to cost approximately $70,000 with equipment.

The Southern Railway has awarded to Dwight P. Robinson & Co. a contract for the design and construction at Chattanooga of a complete locomotive terminal consisting of a reinforced concrete enginehouse, a machine shop, boiler, blacksmith and tank shop, wash and locker buildings, storehouse, office, and oil house, power house, necessary grading, and miscellaneous yard structures.

The Chicago & Eastern Illinois Railway plans the erection of a machine shop and enginehouse at Evansville, Ind., to cost approximately $500,000.

The Chicago & North Western Railway plans the construction of a 6-stall roundhouse addition to its shops at Fremont, Nebr.

The Pennsylvania Railroad has awarded a contract for the electrical work in connection with its building at Sunnyside Yard, Long Island City, N. Y., to cost approximately $62,000.

The Cleveland, Cincinnati, Chicago & St. Louis Railway contemplates the construction of an engine terminal and shops at Riverside, Ohio.

The Chicago & North Western Railway has awarded a contract for the construction of water treating plants ranging from 12,500 to 35,000 gallons per hour capacity at New Butler, Wis., Chadron, Nebr., South Perkin, Ill., New Elm, Minn.

The Maine Central Railroad has awarded a contract for the installation of a new wheel shop, blacksmith shop and passenger car repair track at Rigby, Me., to cost approximately $72,000.

The Terminal Railroad Association of St. Louis contemplates the construction of a car repair shop at St. Louis to cost ap[illegible]mately $50,000 with equipment.

The Missouri Pacific Railroad contemplates the construct[illegible] a repair shop and other improvements, including a 50,000-[illegible] water tank and the installation of a large cinder conveyor at Hot Springs, Ark., to cost approximately $200,000.

The Southern Railway has awarded a contract for the construction of a repair car shop at Knoxville, Tenn., to cost approximately $31,000.

The Chesapeake & Ohio Railway contemplates the construction of a water treating plant at Raleigh, W. Va.

Items of Personal Interest

G. E. Johnson has been appointed master mechanic of the Chicago, Burlington & Quincy Railroad, with headquarters at Wymore, Neb., succeeding **H. C. Gugler**, transferred to Sheridan, Wyo.

J. A. Tschuor, master mechanic of the Baltimore & Ohio Railroad, with headquarters at Akron, Ohio, has been transferred to the Chicago division and **E. J. McSweeney**, master mechanic of the Chicago division, has been transferred to Akron, Ohio.

William Hotzfield has been appointed master mechanic of the Minneapolis, St. Paul & Sault Ste. Marie Railway, with headquarters at Superior, Wis., succeeding **W. F. Buscher**, promoted. **Arthur L. Fillmore** has been appointed master mechanic, with headquarters at Thief River Falls, Minn., succeeding **J. W. Hendry.**

Lewis Archer has been appointed master mechanic of the Virginia division of the Seaboard Air Line Railway, with headquarters at Raleigh, N. C., succeeding **T. C. Price**, deceased.

J. G. Perry has been appointed road foreman of engines of the Chesapeake & Ohio Railway, with headquarters at Peach Creek, W. Va., succeeding **C. H. Wonrack**, transferred to Ashland, Ky., succeeding **G. H. Saunders**, resigned.

Charles A. Bauers has been appointed master mechanic of the Minneapolis, St. Paul & Sault Ste. Marie Railway, with headquarters at Gladstone, Mich., succeeding **A. C. Peterson**, transferred to Stevens Point, Wis.

G. S. Smith has been appointed assistant division engineer of the Colorado division of the Missouri Pacific Railroad.

William F. Buscher has been appointed general master mechanic of the Minneapolis, St. Paul & Sault Ste. Marie Railway, with headquarters at Minneapolis, Minn., succeeding **Louis Ernest**, deceased.

William M. Nelson has been made supervisor of air brakes on the Buffalo, Rochester & Pittsburgh Railway, with headquarters at Du Bois, Pa., succeeding **Harry Sneck**, deceased.

Charles F. Loweth, chief engineer of the Chicago, Milwaukee & St. Paul Railway, had the degree of doctor of engineering conferred on him by the Rose Polytechnic Institute of Terre Haute, Ind.

P. J. Neff has been appointed general superintendent, Eastern district of the Missouri Pacific Railroad, with headquarters at St. Louis, Mo.

F. G. Minnick has been appointed general manager of the

Pittsburgh & Lake Erie Railroad, with headquarters at Pittsburgh, Pa. The office of assistant general manager has been abolished.

E. H. Lee has been appointed president of the Chicago & Western Indiana Railroad, with headquarters at Chicago, Ill., succeeding **H. G. Hetzler**, deceased.

S. U. Hooper, superintendent of the Baltimore & Ohio Railroad, with headquarters at Akron, Ohio, has resigned. He will be succeeded by **H. G. Kruse**, superintendent at Garrett, Ind.

G. W. Simpson has been appointed assistant superintendent of the Atchison, Topeka & Santa Fe Railway, with headquarters at Fresno, Calif.

C. E. Weaver has been appointed chief engineer of the Central of Georgia Railway, succeeding **C. K. Lawrence**, retired.

C. W. Shaw has been appointed superintendent of the St. Louis division of the Illinois Central Railroad, with headquarters at Carbondale, Pa., to succeed **C. R. Young**, promoted.

E. R. Tattershall has been appointed division engineer of the St. Lawrence division of the New York Central Railroad, with headquarters at Watertown, N. Y.

K. R. Vought has been appointed assistant superintendent of the New York division, Pennsylvania Railroad, with headquarters at Jersey City, N. J.

D. C. Reid has been appointed master mechanic of the Indiana Harbor Belt Railroad, with headquarters at Chicago, to succeed **M. L. Zeider.**

P. L. Gaddis has been appointed superintendent of the Southern division of the Florida East Coast Railway, with headquarters at Miami, Fla., to succeed **E. P. McLain**, resigned. **G. A. Miller**, who was superintendent of motive power and machinery, with headquarters at St. Augustine, Fla., retired.

C. M. Kirkby, special representative to the general superintendent of motive power of the Chicago, Milwaukee & St. Paul Railway, has resigned to become mechanical engineer of the Missouri-Kansas-Texas Railroad, with headquarters at Parsons, Kans.

C. F. Moyer has been appointed superintendent of the Ontario division of the New York Central Railroad, with headquarters at Oswego, N. Y.

Henry Shearer has been appointed assistant vice-president and general manager of the Michigan Central Railroad, with headquarters at Detroit, Mich.

Supply Trade Notes

The headquarters of several executives of the **Westinghouse Electric & Manufacturing Company**, East Pittsburgh, have been moved to New York. Among the officials are **M. B. Lambert**, transportation sales manager; **G. H. Froebel**, central station sales manager, and **Bernard Lester**, assistant to the industrial sales manager.

L. G. Plant has been appointed sales agent for special applications of the coal, ash and sand handling equipment of the **Ogle Construction Company**, with headquarters at Chicago. Mr. Plant will continue to represent the **Locomotive Terminal Improvement Company** as general sales agent for the direct steaming system.

Arthur A. Helwig, representative of the **Bradford Corporation**, with headquarters at St. Louis, Mo., has been promoted to manager of the Southwestern district, with the same headquarters, to succeed **W. C. Doering**, who has been elected vice-president, with headquarters at Chicago. **George W. Bender** has been promoted to manager of the Northwestern district, with headquarters at St. Paul, Minn.

The American Steel Foundries has moved its St. Louis, Mo. office from the Frisco building to 1717 Railway Exchange building.

D. A. Corey, vice-president of the **S. F. Bowser & Company** Ft. Wayne, Ind., has resigned.

Roscoe Seybold, formerly manager of price statistics of the **Westinghouse Electric & Manufacturing Company**, has been appointed assistant to **F. A. Merrick**, vice-president and general manager of the company. **Mr. Seybold** has been with the Westinghouse Company since 1907. He served in the price department and later was transferred to the sales department, where he was located for some years prior to his recent appointment. **Francis Hodgkinson**, for many years chief engineer of the South Philadelphia Works, Westinghouse Electric & Manufacturing Company, has been appointed consulting mechanical engineer for the organization as a whole. The position of chief engineer of the South Philadelphia Works has been discontinued. **A. D. Hunt** has been appointed manager of engineering, a newly created position. He has for many years been a member of the engineering staffs of the Westinghouse organization.

Delbert C. Davis and **Charles L. Kenyon** have been appointed assistant treasurers of the **General Electric Company**, Schenactady, N. Y.

A. E. Hitcher, assistant manager of the East Pittsburgh plant of the **Westinghouse Electric & Manufacturing Company**, has been appointed manager of the Los Angeles office.

The Ludlum Steel Company, Watervliet, N. Y., is about to change over its mill from forty to sixty cycle electrical equipment, in order to bring about an increased flexibility and output of its mill as a whole.

The General Railway Signal Company of Rochester, N. Y., has acquired, under license, the right to make and sell, on a royalty basis, the automatic train control systems and train-stop devices of the **Miller Train Control Corporation** in the United States and Canada, under its patents, with the exception that the Miller Company, which is to maintain its own integrity, has reserved for itself its contracts with the Chicago & Eastern Illinois, the Elgin, Joliet & Eastern and the New York Central on which its installations are already in service, and has also reserved the territory of the states of Washington, Oregon, Idaho, Nevada, Arizona and California.

The American Steel & Wire Company has opened a district office for Oklahoma and Kansas at 217 Atlas Life building, Tulsa, Okla., in charge of **George F. Bell.**

Frederick M. Steckman has become associated with **Regan Safety Device Company**, with headquarters at Washington, D. C.

Francis T. West, western manager of the **Watson-Stillman Company** for twenty-five years, with headquarters in Chicago, has retired. He has been succeeded by **J. F. Coyne**, whose headquarters are at 549 West Washington boulevard, Chicago. Associated with Mr. Coyne are **James T. Lee** and **John O. Clark.**

The Osgood Company, Marion, Ohio, has purchased the patterns, drawings and assets of the **Fairbanks Steam Shovel Company** from its receiver, and will continue the manufacture of the latter company's steam and gas shovels and dredges.

A. G. Ripberger, formerly assistant general superintendent of operations of the **United Alloy Steel Corporation**, Canton, Ohio, has been appointed chief engineer, covering all divisions. Mr. Ripberger will be in charge of all phases of engineering and of the operation and maintenance of all power, steam and gas plants.

Justus H. Schwacke, president and a director of **William Sellers & Co. Inc.**, Philadelphia, Pa., resigned and retired to private life. Mr. Schwacke had been with the Sellers Company continuously since July, 1862. He was elected secretary when the company was incorporated in 1886, director in 1902, manager in 1905 and president in 1922. **Alexander Sellers** was elected president of William Sellers & Co., Inc., following the resignation of Mr. Schwacke. Mr. Sellers has been with the company since 1896, a director since 1902 and vice-president since 1905.

Robert B. Jennings, formerly division engineer of the Canadian National, with headquarters at Montreal, Que., has been appointed general manager of the **Robert W. Hunt Company, Ltd.**, with headquarters at Montreal.

Lawrence A. Luther, for seven years motor car and tie tamper maintainer for the **Delaware, Lackawanna & Western Railroad**, joined the ranks of the **Ingersoll-Rand Company**, and will continue the same line of work with that company.

Loyall A. Osborne, president of the **Westinghouse Electric International Company**, was elected chairman of the **National Industrial Conference Board** at the tenth annual meeting of that organization in New York City.

H. C. Vickerman, who was with the **Oil Well Supply Company**, has joined the sales forces of the **Reading Iron Company**, and will represent them in California, with headquarters in the Van Nuys building, Los Angeles, Calif.

B. A. Clements has been elected president of the **Rome Iron Mills, Inc.**, with headquarters at New York, to succeed **Edward M. Zehnder**, who died at his home in Scranton, Pa., on June 21.

W. C. Lloyd has been appointed representative of the **Milwaukee Crane & Manufacturing Company**, with headquarters at Pittsburgh, Pa.

The Graybar Electric Company has removed its Buffalo, N. Y., branch office from 709 Main street to 77-79 Swan street.

The Alloy Cast Steel Company, of Marion, Ohio, has recently been organized for the manufacture of electrical steel castings in carbon, manganese, and other alloy steel. The company has purchased the electric steel foundry of the **Fairbanks Steam Shovel Company** and the plant is being overhauled and enlarged to a capacity of 400 tons of steel castings a month.

The Buda Company, Harvey, Ill., announces the removal of its southwestern district factory sales office from Fourth and

Detroit streets, Tulsa, Okla., to new quarters at 311 East Second street.

Charles V. Allen, assistant treasurer of the **Westinghouse Electrical International Company**, has been elected treasurer and assistant secretary to fill the position recently left by the resignation of **H. A. Carmichael.**

New Publications

Books, Bulletins, Catalogues, Etc.

Pneumatic Tool Pocket List for Railway Shops—The Ingersoll-Rand Company has issued a handbook covering the principal uses of pneumatic tools in railway shops. It contains 107 pages and is well illustrated from actual photographs taken in different railway shops.

It contains a complete description of the use of air tools, the size of tool recommended for each of the operations is also given.

The book has been made to slip into the pocket and contains an index and table of contents in the front part of the book enables ready reference to any particular application.

This handbook may be obtained by addressing the company at 11 Broadway, New York City.

Safety Lighting Equipment for Gasoline Railroad Cars—The Safety Car Heating & Lighting Company has issued a leaflet containing 8 pages describing car lighting generators, generator regulators, and lamp regulators for gasoline rail cars. The former equipments has not been satisfactory for this type of service, and the standard steam railroad train lighting generator were too heavy. It also gives useful information concerning the production of complete lighting equipment suitable for gasoline cars but still retaining standard railroad voltage. Copies of this leaflet may be obtained by addressing the company at New Haven, Conn., or from any district office.

Thirty-eighth Annual Report on the Statistics of Railways in the United States for the Year December 31, 1924—Compiled by Bureau of Statistics, U. S. Interstate Commerce Commission. Two hundred and seventy-five pages. Washington, Government Printing Office, $1.50. The latest I. C. C. "Blue Book" containing the usual text outlining transportation developments generally and containing selected figures for 1925, and the tables of detailed statistics by railroads. The text is available as a separate pamphlet (price 15 cents from the Government Printing Office), and is a most useful reference work for those interested in transportation.

Locomotive Feedwater Heater—The Worthington Pump & Machinery Corporation has issued a bulletin Np. BK-1607-D, which contain 28 pages. Charts for the computation of heat recovery and exhaust steam condensed and returned to the boiler with open type feedwater heater operation are contained in this bulletin. The second half of the bulletin is devoted to locomotive photographs showing installations throughout the United States and Europe and the technical phases of feedwater heating are dealt with to some extent. Copies of this bulletin may be obtained by addressing the company at 115 Broadway, New York City.

The Railway and Locomotive Historical Society, Brookline, Mass., has issued its eleventh historical bulletin which contains 44 pages. It contains an article on the Collection of Locomotives at Purdue University, and an article on George Althouse, a pioneer locomotive engineer who flourished in the last century, and an article on locomotive builders of Paterson, N. J., which is very interesting as well as being illustrated by pictures of typical engines; an article on Jarrett and Palmer special, also a short historical sketch of the Cheraw and Darlington and Cheraw and Coalfield Railroad.

Aluminum Bus Body—The Aluminum Company of America has issued a pamphlet entitled, "A Revolution in Transportation," which describes the eight wheel gas-electric highway coach developed by the Versare Corporation in which an extensive use of aluminum is made in building up the body of the coach. Copies of this pamphlet may be obtained by addressing the company at Pittsburgh, Pa.

Three-Cylinder Locomotives—The American Locomotive Company has issued Bulletin No. 2003 illustrating and giving the principal dimensions, weights and proportions of a number of three-cylinder locomotives, among which are the Union Pacific and Overland types built for the Union Pacific, the Southern Pacific type built for the Southern Pacific, the Lehigh Valley type built for the Lehigh Valley, and the Mohawk type built for the New York Central Lines. The bulletin also contains the paper on the three-cylinder locomotive by J. G. Blunt, read before the Chicago section of the American Society of Mechanical Engineers. Copies of this bulletin may be obtained by addressing the company at 30 Church street, New York City.

The Superheater Company, 17 East 42nd street, New York City, has issued two booklets, one which contains a brief story of the locomotive superheater and the part it plays on the American railways of today. It also states what a superheater does for a locomotive, and points to the necessity of giving a reasonable amount of attention to the superheater to obtain best results. The other booklet, "Elesco and the Railroads," gives facts about Elesco superheaters, feed-water heaters, exhaust steam injectors, and the superheater units reclaiming service offered by this company. Copies of these booklets may be obtained by addressing the company.

Railway and Locomotive Engineering

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The Ljungstrom Turbine Locomotive

Condensing Turbine With Direct Drive Through Reduction Gears—Shows Efficiency and Reliability in Service

In 1922, announcement was made that a turbine locomotive designed by Frederick Ljungstrom was placed in service on the Swedish State Railways. On the basis of experience, this locomotive was removed from service and some of the parts were redesigned, notably the stationary type air preheater was replaced with a rotating design that had been used with marked success in power plant service. Since October, 1923, the engine has been operating in various classes of service.

Ljungstrom Steam Turbine Locomotive In Service on the Swedish State Railways

Early in 1923 an order was placed by the Swedish State Railways with Nydquist & Trollhattan, Sweden, for the construction under the license of the Ljungstrom Steam Turbine Company of a second turbine locomotive generally similar in construction to the original locomotive as it has now been modified. This new locomotive has a total weight of approximately 322,000 lbs., including both the boiler vehicle and the condenser vehicle, under which the driving axles and turbine are located. It develops 2,000 effective horsepower at the rail and is designed for a maximum speed of 60 miles an hour, to meet the limitations of speed imposed by the Swedish State Railways. An order was also placed by the Argentine Republic Government with the same builders for a locomotive of this type to develop 1,750 brake horsepower, to burn oil fuel. This locomotive was built under a guarantee calling for a fuel and water capacity sufficient for a 500-mile run lasting 20 hours without replenishing. About 23,500 lbs. of water will be carried, approximately half in the condenser and the remainder for feed water. The fuel requirement is 14,500 lbs. of oil having a heating value of 18,900 b.t.u. per lb.

The Swedish company has guaranteed a 50 per cent fuel saving during the cold season and a 40 per cent saving during the warm season.

In 1925, Beyer, Peacock & Company, Ltd., of Manchester, England, designed and constructed a Ljungstrom turbine locomotive to meet British railway conditions.

The locomotive consists of a boiler carrying vehicle and a turbine driven condenser vehicle, the latter having three pairs of coupled and driving wheels. The drive from

the main turbine to the driving wheels is transmitted by means of direct double helical gearing having three reductions, the ratio of the gearing being 1 to 25.22, the final drive from the last gear shaft to the driving axle being by means of a quill or hollow axle operating through links, giving a flexible connection to the driving wheels. Coupling rods are used for the drive of the intermediate and trailing coupled wheels. The main gearing is contained within a dust proof casing, slung to the main frames in such manner as to allow for movement of the frames.

Owing to the space retween the driving wheels being fully occupied by the gear casing and flexible drive, the main frames are placed outside the wheels with outside axle boxes and crank arms; a four-wheeled truck carries the trailing end of the vehicle.

Main Turbine and Condenser

The main turbine is of the axial flow type giving an output of 2,000 h.p., and has a speed of 10,000 r.p.m. for an engine speed of 70 miles per hour, the driving wheels being 5 ft. 3 in. diameter. Such speed will, of course, be attainable as, owing to the complete absence of reciprocating parts, the engine can be perfectly balanced. The turbine is fixed to the condenser body and flexibly connected to the main gearing by means of flexible couplings.

Reversing is effected by means of an idle shaft and gears operated by hand or oil gearing. The condenser is of the Ljungstrom patent air cooled type with auxiliary water surface condenser the water being carried in the main condenser body and forming the supply for the boiler. The condenser elements are of copper tube, flattened and ribbed in accordance with the Ljungstrom method. They number approximately 2,500 arranged in batteries, and are fixed vertically on each side of the condenser vehicle to top and bottom collector castings, the top collectors receiving steam from the turbine exhaust and the bottom collectors receiving the condensate. Condensation is effected by means of air drawn, by four powerful fans, through the spaces between the elements, the fans having their own driving turbine, the speed of which may be regulated to suit the required conditions. A circulating pump for the water in the condenser body is also provided and is operated from the fan driving shaft. The condensate is conveyed to a sump, from which it is transferred to the condenser body by means of a diffuser and lifter.

Two turbine-driven centrifugal pumps are provided for feeding the boiler and the water forced through a tubular feed-water heater on its way to the boiler, the feed heater serving to condense the exhaust steam from the pumps and other auxiliaries. Exhaust steam from the pumps is also conveyed to the main turbine packings, ensuring air tightness.

Boiler Details

The boiler vehicle is carried on three fixed axles and the four wheeled leading truck. The boiler is of the ordinary locomotive type with Belpaire firebox and inner firebox of steel with steel stays. The tubes are of steel 2½-in. outside diameter, and fitted with a small tube superheater giving a high degree of superheat. The boiler is constructed for working pressure of 285 lb. per square inch.

The smokebox contains an air preheater of the Ljungstrom patent design, having a revolving rotor fitted with thin nickel blading, the blades being alternately heated by the combustion products, and cooled by the incoming air: the heated air is then conveyed to the closed ashpan and firegrate by means of a special air duct. A turbine driven draught fan is fixed to the front of the smokebox and is under the control of the fireman from the cab. The front portion of the smokebox containing the air preheater is made easily movable on hinges to give access to the tubes, etc., exhaust from the turbine is taken direct to the condenser.

Steam is conveyed from the boiler to the turbine by means of the usual piping, but in the case there are two regulators, one in the dome, which is always open when the engine is in service, and a second one near the main turbine, by which the operation of regulating the admission of steam is performed. The steam pipe between the regulator, including superheater, is therefore always filled with steam, and from it are taken all the steam pipes for the auxiliaries. A ball and socket joint is provided to allow for the relative movement of the two vehicles, the coupling between the vehicles being a fixed type allowing for radial movement only.

The operating gear for the regulators, as also for the auxiliaries, is placed conveniently for the locomotive crew. A coal bunker holding six tons of coal is fixed in the usual position and side tanks for 600 gallons are placed at the side of the boiler. This quantity of water is provided as an auxiliary supply in order to make up the unavoidable small losses from leakage, whistles, etc., without diminishing the water contained in the condenser body. A float valve fixed on the condenser controls the admission of water from the side tanks.

The engine is constructed for the standard, 4 ft. 8½ in. gauge. The boiler characteristics are as follows:

Length of barrel	9 ft. 1 in.
Diameter outside	6 ft.
Heating Surface:	
Tubes	1,480 sq. ft.
Firebox	140 sq. ft.
Superheater	640 sq. ft.
Grate area	30 sq. ft.
Working pressure	285 lb. per sq. in.
Heating surface of air preheater	13,500 sq. ft.
Cooling surface of condenser	13,500 sq. ft.
Horsepower of main turbine	2,000
Tractive effort, maximum	38,000 lb.

The locomotive is designed for a maximum speed of about 75 miles per hour. The cab is of commodious design with side doors and windows, roof ventilator and the usual fittings. The boiler vehicle is fitted with a steam and hand brake.

The principal weights are as follows:

Weight on front truck	60,480 lb.
Weight on forward rigid wheel base	89,040 lb.
Weight on drivers	126,560 lb.
Weight on rear truck	42,560 lb.
Total weight in working order	318,640 lb.

Performance Record

The only available figure on the performance record of the Ljungstrom design of turbine locomotive have been made available by C. E. Uddenberg, Chief Engineer of Machine Equipment of the Swedish Government Railways at Stockholm, Sweden, whose records indicate that a fuel economy of 45 per cent in regular service has been obtained in comparison with an up-to-date ordinary engine of corresponding capacity in use on the lines referred to.

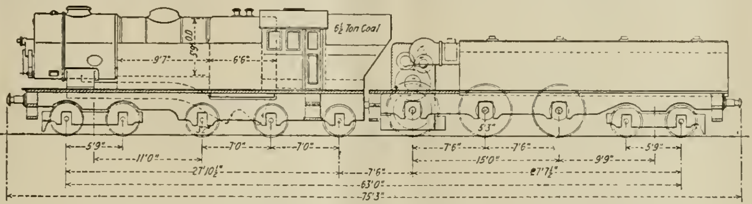
The usual weight of the train, exclusive of the locomotive, was 350 to 375 tons. On one occasion, however, the train weighed 718 tons, and on another, 709 tons over the last part of the trip, which included several long one-per cent grades. The performance of the locomotive in starting and accelerating the heaviest of these trains is said to have been entirely satisfactory.

After completion of the local freight trials, the locomotive was taken out of service and carefully inspected. The

auxiliaries, including the induced draft fan, the turbine and gearing for the condenser fan, and the turbine driven boiler feed pump, were dismantled in order to determine the extent of the wear which might have developed in the bearings. None could be discovered, however, and the only defect found was one boiler tube leaking. With this exception no repairs have been necessary, except such as the renewal of brake shoes, etc.

The locomotive was first used running express train service on the main line between Stockholm and Gothenburg, alternately on passenger trains making frequent stops, and on fast express trains. About half of the distance between Stockholm and Gothenburg constitutes the run of the turbine locomotive, which is averaging about 250 miles per day. The average weight of the train, exclusive of the locomotive, is about 300 tons.

The locomotive is said to have developed marked accelerating capacity with freedom from jerks and shocks in starting the train. Its capacity for handling this service has been demonstrated a number of times by its ability to make up lost time on the schedules.



Ljungstrom Turbine Locomotive Designed For Service in Great Britain

The performance of the Ljungstrom locomotive has proven so successful that in the early part of last Spring one of these locomotives was placed in regular service on the night express run between Stockholm and Gothenburg to cover the entire distance which previously, when the F.-type reciprocating locomotive was used had been divided in three divisions, each with its own engine and crew.

The advantages claimed for Ljungstrom turbine locomotives may be summarized in the following points:

1.—A very great saving of fuel.

2.—Minimum consumption of water on account of the condensing system with which only the quantity of water represented by the leakage of steam is lost.

3.—On account of the small consumption of fuel and water the turbine's locomotive can carry sufficient quantities for long distances, and may consequently be used over distances which, as a rule, require several locomotives.

4.—Smooth running of the engine and the ease with which it can be handled.

5.—Higher efficiency of the boiler owing to rational preheating of the combustion air.

6.—The use of condensed water for feeding the boiler prevents the formation of scale.

7.—The fire risk is reduced because sparks from the furnace are extinguished in the preheater.

8.—More efficient starting power due to using turbines.

9.—Reduced wear on the rails because of the absence of reciprocating weights.

10.—Reduced wear on the couplings on account of the absence of jerks.

After very thorough tests it is claimed that the turbine locomotive consumes only about half as much coal as a modern locomotive with reciprocating engines. The consumption of water was only 2 tons on a distance of 74 miles in comparison with 45 tons, for an ordinary locomotive. Besides this exceedingly small consumption of water, which is of vital importance in certain regions of the earth, and the very considerable saving of fuel, is another factor of extreme importance these days.

The turbine locomotive, while it may show much economy in operation, the initial cost is extremely high when compared with the ordinary steam locomotive.

Maintenance Costs of Rolling Equipment

The most economical unit for the transportation of goods in the United States is the freight car. This is partly the result of the inherent advantages of steam transportation when compared with other forms and partly a tribute to the competence of railroad management.

In the maintenance of its cars and locomotives, the railroad performs one of its great unseen services for modern society. The Bureau of Railway Economics has just made an analysis of these expenditures for the year 1925.

This shows that in 1925 the railroads had to spend $155 per freight car to keep it in running order; $1,552 per passenger car; and $7,023 per locomotive. These expenditures seem small enough in themselves; the maintenance of a freight car, for instance, costing hardly more than a set of tires for a good automobile. Yet, multiplied by the 2,400,000 freight cars on the Class I railroads of the country it means an expenditure of $372,141,252.

Maintenance expenditures of $1,552 per passenger car mounted up to $83,812,056 for the 54,000 passenger train cars on Class I railroads.

Maintenance expenditures of only $7,023 per locomotive amounted to $456,532,575 for the 65,000 locomotives in service on the Class I railroads.

When to this are added the expenditures on work locomotives, motor cars, floating equipment and work cars, we get the grand total of $946,245,179.

This total is exclusive of depreciation and retirement allowances on equipment and does not include any of the overhead cost of management and supervision.

Maintenance of equipment expenditures are approximately 20 per cent of the total annual expenses of operating the railroads and constitute one of the unseen elements of cost required to provide the country with adequate, efficient and safe transportation.

The amounts directly charged to equipment repairs, exclusive of depreciation, retirements and miscellaneous items, were as follows:

Repairs of	1924	1925
Steam locomotives	$465,131,860	$456,532,575
Other locomotives	2,656,890	2,736,110
Freight-train cars	380,925,733	372,141,252
Passenger-train cars	85,972,479	83,812,056
Motor equipment of cars...	1,932,513	2,018,353
Floating equipment	11,938,807	10,722,784
Work equipment..........	17,723,279	17,907,280
Miscellaneous equipment ...	304,716	374,769
Total	$966,586,277	$946,245,179
Repairs per passenger car..	$1,592	$1,552
Repairs per freight car.....	158	155
Repairs per locomotive....	7,155	7,023

Regenerative Braking for Direct-Current Locomotives

A Paper Presented to the American Institute of Electrical Engineers

By A. Bredenberg, Jr., Railway Department of the General Electric Company

It is not the purpose of this paper to give an exhaustive discussion of the question of regenerative braking, but to make a comparative study of some of the systems now in successful operation on direct-current locomotives.

General Characteristics

Whenever it is proposed to electrify a railroad, where grades exceeding 6 per cent form an appreciable part of the line, the possibility of applying regenerative braking is usually considered on account of its marked advantages. These are, briefly, as follows: reduced wheel and brake shoe wear; increased safety due to reduced tire heating and brake shoe wear and to the fact that duplicate braking systems are provided; higher average speed descending grades, since a very uniform speed can be maintained; elimination of delays due to inspections, worn out brake shoes, etc.; saving of power returned to the line; and increased comfort to passengers as a result of the uniform speed and elimination of noises and shocks caused by the air brake system. Against these advantages must be balanced the increased weight, cost of maintenance of the equipment.

Although regenerative braking may be used to reduce train speeds to a certain extent, and systems have been designed to slow down a train or car to very low speeds, yet the primary purpose of this method of braking, as applied to heavy traction service, is to hold the train at a uniform speed down a given grade. Regenerative braking should not be over-emphasized as an emergency braking system. This method of braking can only be applied to the locomotive, whereas, in the air brake system, the brakes may be applied to every car in the train. Regeneration, therefore, does not replace the air brakes or lessen the reliability required of them but should be considered as a means of braking, supplementing the air brakes, which has some very decided advantages as has been outlined.

Regenerative braking is, of course, particularly applicable to long, heavy mountain grades and is generally used in such service on account of its obvious advantages. However, it is applicable to comparatively light or short grades, provided that the results obtained are commensurate with the extra cost incurred.

In order to raise the voltage of a direct current series motor to cause it to return power to the line, it is necessary to separately excite the series field and to control this excitation so that smooth operation is obtained regardless of changes in line voltage or grade.

Methods of Field Excitation

There are two general methods of exciting the motor fields, both of which have been successfully applied. One method is the use of a generator which may be driven by a motor operating from line voltage or from a dynamotor. It might also be mechanically driven from an idle axle of the locomotive.

Chicago, Milwaukee & St. Paul High Speed Gearless Electric Passenger Locomotive

The other method is to use one or more of the traction motors to excite the fields of the remaining motors. This method may be further sub-divided according to the method of controlling the exciter field. Thus, in one case, the exciter field is controlled by contactors, resistors, etc., especially provided for that purpose, while in the other case control of the exciter field is obtained by means of the same contactors and resistors that are used in accelerating the locomotive.

C. M. & St. P. Freight Locomotives

The method of exciting the regenerating motor fields by means of a motor-generator set operated from the line voltage was first put into commercial use on the Chicago, Milwaukee and St. Paul, 3,000-volt freight locomotives. Referring to Fig. 1, which shows the regenerative connections of one-half of one of these locomotives, the exciter is so connected that the exciter armature current is the sum of the motor field current and the regenerated current. Control of the exciter field is obtained by means of a motor operated rheostat, automatically controlled by

a current limit relay, which is connected in the exciter armature circuit. The current limit relay thus is responsive to the sum of the motor armature and field currents. Control of the braking speeds is obtained by changing the setting of the current limit relay by means of the braking handle on the master controller.

Compensation for sudden surges in current, due to changes in line voltage or grade, is obtained by a combination of several factors, viz., the differential series field

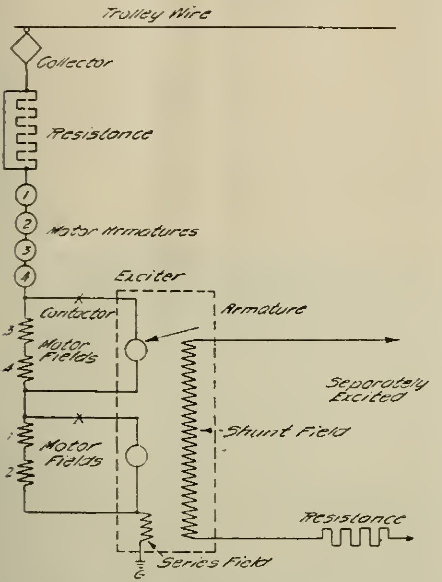


Fig. 1—Regenerative Connections for one-half C. M. & St. P. Freight Locomotive

of the exciter, the exciter armature reaction and the resistance drop in the exciter armature circuit. For example, assume a sudden decrease in line voltage. This will tend to rapidly increase the regenerated current and consequently the current through the exciter armature. The compensating factors will then operate as follows: the differential series field and the exciter armature reaction will tend to weaken the exciter field and reduce the exciter voltage, thus reducing the motor field current, while the increased resistance drop will cause the exciter armature circuit to absorb more of the exciter voltage and thus further reduce the field current and generated voltage of the traction motors. Likewise a sudden decrease in regenerated current will be compensated for in just the opposite manner. Thus the inherent characteristics of the exciter circuits prevent excessive surges of current and torque and allow time for the circuits to readjust themselves to the changed operating conditions.

Mexican Locomotives

Another application of the method of exciting the motor fields by means of a separate motor-generator set is that of the Mexican Railway, 3,000-volt locomotives. In this case, the regenerative exciter is driven by a 1,500-volt motor, which is connected to the mid-point of a 3,000/1,500-volt dynamotor. Connections for this locomotive are shown in Fig. 2. In this case the exciter carries the motor field current only. Control of locomotive speeds is obtained by adjusting the exciter voltage by means of a variable resistance in the exciter field circuit. This adjustment is obtained directly by means of the braking handle of the master controller.

Compensation against sudden surges in line current is provided by balancing resistances, which carry the sum of the field and armature currents. Thus, for example, if the line voltage drops suddenly, this will tend to produce a rapid increase in regenerated current. The increase in current causes an increased voltage drop across the balancing resistance, which causes a decreased voltage and current in the motor field circuit. This reduces the regenerated voltage of the motors, thus preventing an excessive change in regenerated current. Similarly, when passing from one control step to another, the balancing resistance aids in producing smooth operation by reducing current and torque increments between stops.

Comparison of C. M. & St. P. and Mexican Locomotives

Comparing these applications, in one case the exciter carries the sum of the motor armature and field currents while in the other case the exciter carries the field current only. This means that in the latter case the exciter armature current will be halved. At the same time the exciter voltage will be increased as the exciter must overcome both the voltage drop in the motor fields and in the balancing resistance. However, experience has demonstrated

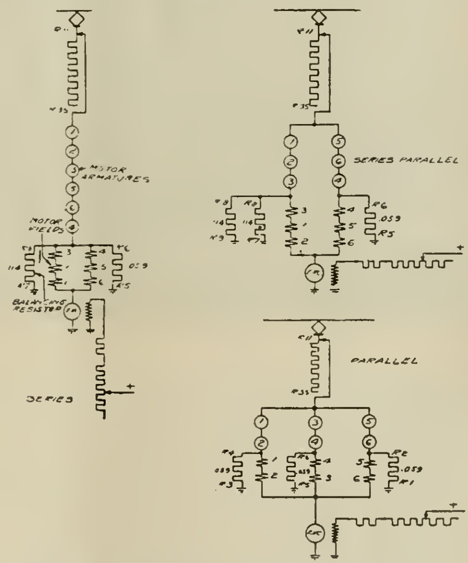


Fig. 2—Mexican Electric Locomotive Connections

that the drop through the balancing resistance can be held to such a value that the net result is a reduction in kilowatt capacity required of the exciter.

In the first system described, compensation is obtained by means of exciter differential field, armature reaction and resistance drop. In the second system a resistance alone is used since tests and operating data have demontrated that a very effective compensation can thus be provided. The second system will tend to be less efficient on account of the losses in the balancing resistances. However, a much simpler control is thus provided and, furthermore, it is very easy to make adjustments by providing taps in the balancing resistances.

Comparing the operating characteristics, the system

used on the Mexican locomotives has the characteristic of relatively small changes in speed with changes in the braking effort required. The result is that changes in grade or curvature will cause smaller speed changes in this case than with the C. M. & St. P. system. In brief, the Mexican system tends toward a constant speed characteristic while the C. M. & St. P. system tends toward a constant torque characteristic.

The ideal characteristic for regenerating motors would be a characteristic similar to that obtained in motoring operation with a series motor where the armature and field currents are equal throughout the operating range. This would give a very stable electrical characteristic but an extremely unstable speed characteristic as the braking effort would decrease very rapidly with increases in speed.

The ideal characteristic from a mechanical standpoint would be one in which the speed on any controller notch is held constant regardless of changes in braking effort required. Such a characteristic would be approximated with constant field excitation. Such a system would be very unstable electrically since very large changes in armature current would occur with small changes in speed. This would be particularly undesirable at high speeds on account of the relatively weak fields required.

In practice, a compromise must be made between these two extremes. From the standpoint of train operation it is very desirable to obtain a uniform speed for any given controller notch. Some speed variation must be allowed, however, in order to obtain the desired stability of the motors. Such is the case with the two systems described above. In each case, for any given controller notch within the regenerating range of the motors, with increases in speed, sufficient increase in braking effort is obtained to give mechanical stability but at the same time the speed regulation is not made so close as to sacrifice the desired electrical characteristics.

With the more constant speed characteristic of the system used on the Mexican locomotives, very little manipulation of the master controller is required to hold the train at a practically constant speed. This has been demonstrated in actual operation on the Mexican Railway. The electrified section of this railway is 45 kilometers long and regeneration is obtained for about two-thirds of this distance, the grade being about 4.7% for the greater part of the distance.

The principal advantage of the Mexican system is its simplicity. Compensation for line voltage changes is obtained by means of a simple resistance and control of the regenerating speeds is obtained by hand control of a resistance in series with the exciter field. No relay or motor-driven rheostat is used. This will reduce the first cost of the system and keep the maintenance required to a minimum.

Development of Method of Control of Exciter Field

The steps in the development of the method of controlling the exciting generator field included experiments with the sensitive type of regulator used with stationary units. Later the motor-operated field rheostat was used and finally direct hand control of the field was adopted, compensation against voltage and speed fluctuations being obtained by the inherent characteristics of the motor field circuits, without the addition of any regulator or moving parts.

Six Axle Geared Electric Locomotive of the Mexican Railway

Axle Generator System

The axle generator system may be considered as a motor-generator set system in which the motor of the motor-generator set is replaced by the axle driving mechanism. The same method of control may be used in either case.

The principal differences between an axle generator system and the corresponding motor-generator set system are that the axle generator is necessarily a slow speed machine; it varies in speed with the speed of the locomotive and the driving torque of the axle generator is available to aid in braking the train.

Assuming that the same connections are used for an axle generator system as are used on the Mexican locomotive, Fig. 2, it may be readily seen that with an increase in speed due to an increase in the grade, the regenerated voltage and current will tend to increase both due to the increase in speed of the motors themselves and to the increase in speed of the axle generator which thus

tends to increase the motor field current. This tends to give a very close speed characteristic for any given excitation of the axle generator field. This is to be desired provided that the electrical stability of the motors is not lessened.

In regard to the added braking effort of the exciter, this might prove an advantage in freight service where it is often desired to handle a considerably heavier train down grade than could be hauled up the same grade by

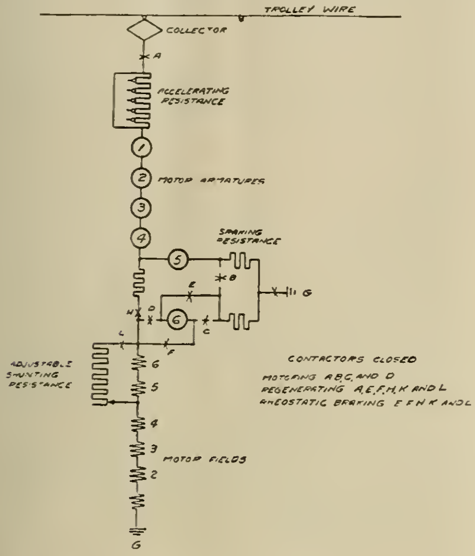


Fig. 3—Regenerative Connections for one-half C. M. & St. P. Gearless Passenger Locomotive

one locomotive. However, in this case it will probably be necessary to use the air brakes on the train in conjunction with the regenerative braking so that little would actually be gained from the additional braking effort obtained from the axle generator. Furthermore, there must be an idle axle available to drive the exciting generator. This is usually the case with passenger locomotives. However, on freight locomotives, very often there are no idle axles, as illustrated by the Mexican and Spanish Northern locomotives and the Paulista freight locomotives, where every axle drives a traction motor.

Another limitation of the axle generator is that, due to its low speed, it must be of relatively large size. In addition it must deliver practically the same output over a wide range of speeds which will tend to compromise the design and complicate the control. Furthermore, the axle generator is mounted close to the track and thus is subject to more abuse, dust particles, etc., than a generator mounted in the locomotive cab.

C. M. & St. P. Gearless Passenger Locomotives

In order to eliminate the use of a separate generator for field excitation, the method of using one or more traction motors as a regenerative exciter was developed. The first application of this system to heavy traction service was on the C. M. & St. P. 3,000-volt gearless passenger locomotives. Fig. 3 shows the regenerating connections for one-half of the locomotive. The two halves may be operated in series or in parallel when regenerating so that two combinations of regenerating motors are obtained, one with eight motors in series and the other with two parallel groups of four motors in series in each. In each six-motor group, two of the traction motors are used to excite the fields of all six motors. Control of the excitation is obtained by means of a variable resistance which shunts the fields of the exciting motors. This resistance is adjusted by means of contactors which are controlled by the braking handle of the master controller.

From the connections it will be seen that the sum of the field and armature currents of the regenerating motors passes through the two exciter armatures which are connected in multiple and that an external resistance is connected in series with each of the exciter armatures. This system thus provides an inherent regulation against line current surges which is in effect a combination of the C. M. & St. P. freight and the Mexican systems. That is, the sum of the armature and field currents of the regenerating motors passes through balancing resistances and also through the exciter armatures. An effective means of compensation against surges is thus provided.

A further simplification of the apparatus required for regeneration may be obtained with the traction motor exciter system by using the same resistances and contactors for controlling the exciter during regeneration, as are used during acceleration of the locomotive. This system is now in successful operation on the Paulista, four-motor, 3,000-volt locomotives and on the Spanish Northern, locomotives one traction motor is used to excite its own field and the field of the other five motors which are connected in series to the line.

Paulista Locomotives

Figure 4 shows the schematic connections of the Paulista locomotive both motoring and regenerating. It will be seen that there are two motor combinations motoring, one with all four motors in series, with 750 volts ap-

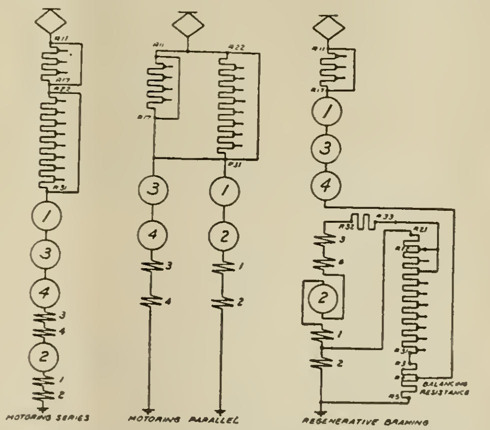


Fig. 4—Schematic Connections for Motoring and Regenerating Paulista Locomotive

plied per motor, and the other combination with two groups of two motors in series in each, with 1,500 volts applied per motor. There is one regenerating combination with the three regenerating motors connected in series, with a normal voltage of 1,000 volts per motor. By referring to the resistance symbols, it will be seen that part of the accelerating resistance is connected in series with the regenerating motors. This resistance issued in connecting the motors to the line when establishing the regenerative connection. It is short-circuited during regeneration. The remainder of the accelerating resistance is connected in the motor field circuit and is thus used to

control the regenerative operation. Some additional resistance and additional contactors are required, but it is to be noted that an appreciable saving in equipment is made by using the accelerating resistances and contactors for control of the exciter field.

Practically the same method of compensation for line current surges is used as on the Mexican locomotives. A balancing resistance is connected in the circuit so as to carry the sum of the line current and the exciter field current. This exciter field current is also part of the regenerating motor field current so that the compensation is

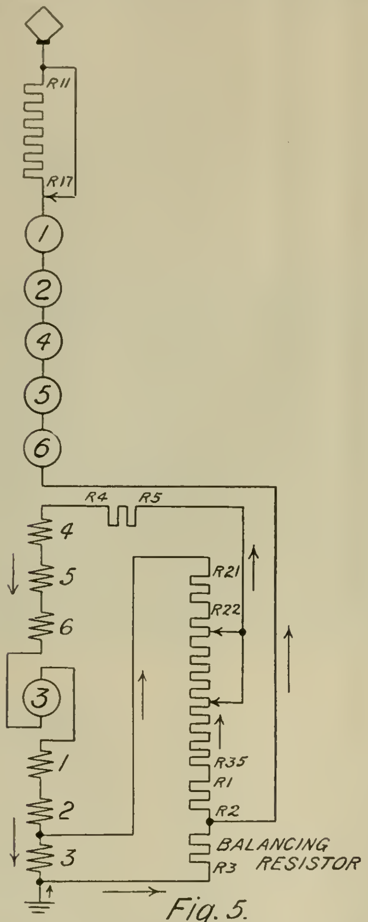


Fig. 5.

Regenerating Connections of Spanish Northern Locomotive

obtained in two ways; directly by the effect of the balancing resistance on the regenerating motor fields and indirectly by the effect of the balancing resistance on the exciting motor field.

Spanish Northern Locomotives

On the Spanish Northern locomotives, there are two motoring combinations, one with all six motors in series, with 500 volts applied per motor, and the second with two parallel groups of three motors in series in each, with 1,000 volts applied per motor. Fig. 5 shows the regenerating connections of this locomotive. One of the six motors is used to excite its own field and the fields of the other five motors, which are connected in series to the line with a normal voltage of 600 volts per motor. Otherwise, the regenerating system is identical with that of the Paulista locomotives.

Comparison of Methods of Field Excitation

In order to obtain a comparison of the system using a separate generator for field excitation and that using traction motor excitation, a study was made of the operating characteristics of a locomotive similar to the Spanish Northern six-motor, two-speed, 3,000-volt locomotive as compared with the same locomotive with a motor-generator set for field excitation. For motor excitation, then, there will be one regenerating combination with one traction motor exciting the other five, all connected in series.

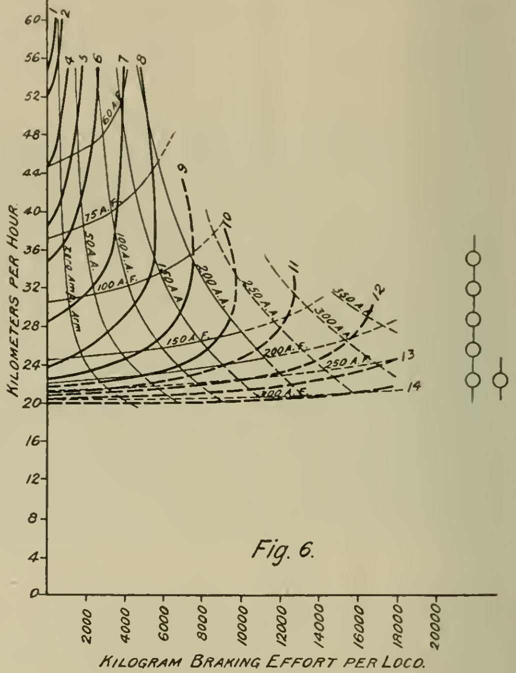


Fig. 6.

Relation Between Speed and Braking Effort

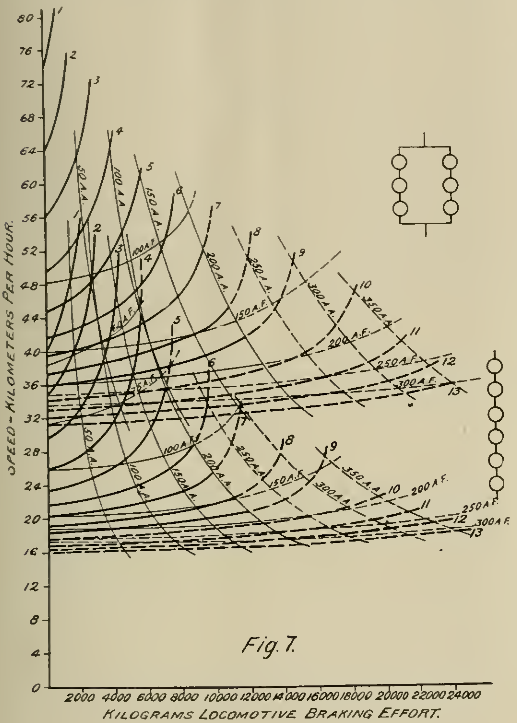
For separate excitation there will be two regenerating combinations, one with all six motors in series and the second with two parallel groups of three motors in series in each, these combinations being the same as those obtained while motoring.

In comparing the operating characteristics of these two systems of regeneration, the main points to be considered are: range of operating speeds, train weights which may be handled, slope of grades, mileage on which regeneration can be used and reliability.

Figures 6 to 8 inclusive, illustrate the speed-braking effort characteristics obtained with the two systems. Figures 6 to 7 give the relation between speed and braking effort for each step of the braking handle on the master controller and Fig. 8 is a composite diagram which shows the range of speeds and braking efforts which may be obtained in each case. The shaded areas in Fig. 8 give the continuous operating ranges, while the unshaded areas give the ranges within which the locomotive may regen-

erate for short periods. This diagram also shows the speed tractive effort curves for motoring operation in each of the two motoring connections. In each case the full field and two reduced field characteristics are given. The tractive effort and speeds at the continuous current rating are also indicated.

Two regenerating speed ranges are obtained with the separate excitation system whereas one speed range is obtained with motor excitation, this latter speed range being intermediate to the two speed ranges with separate excitation.



Relation Between Speed and Braking Effort

In analyzing these curves it is to be noted that with the same line voltage, the same motor combination and the same armature and field current, a slightly higher speed will be obtained when regenerating than when motoring. The reason for this is the reversal of the affect of resistance drop in the motor circuits. Under the same conditions the braking effort regenerating will be appreciably greater than the corresponding tractive effort motoring on account of the reversal of the effect of the motor loses on the torque and the driving wheels. Furthermore, with a given torque at the driving wheels, it will be possible to handle a considerably heavier train down grade than up grade since the train and curve friction oppose the locomotive ascending the grade, while they assist the locomotive when descending.

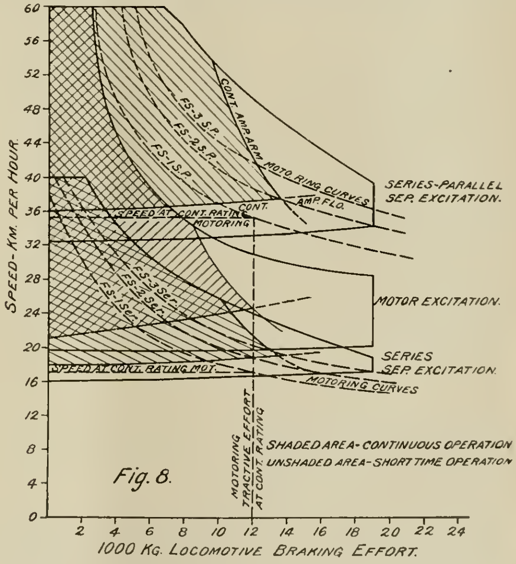
With the separate excitation system, therefore, the regenerating speeds will be a little higher than the motoring speeds with the same motor combination, voltage and currents. With motor excitation of fields, in this particular case, the regenerating speed, at the continuous current rating of armatures and fields, will be about 70 per cent of the corresponding motoring speed. As a rule, the double speed range is to be preferred unless it is desired to descending the grade at a lower speed than ascending. In the latter case the speed range of the motor excitation system will probably be more suitable.

From an analysis of the curves, it may be seen that for a given armature and field current of the regenerating motors, a greater braking effort is obtained with the separate excitation system than with the motor excitation system. The reason for this is that, in the former system, the full braking effort of all six motors is available, while in the latter the full braking effort of five motors and a fraction of the full braking effort of the exciting motor is available. The result is that greater train weights can be handled down a given grade with the separate excitation system than with the motor excitation system.

The following conclusions in regard to operating characteristics may be stated as a result of the comparison of these two systems:

(1) With motor excitation, in general, on all grades the same train can be handled down hill as up hill, but at reduced speeds. This reduction in speed will be comparatively small for light grades but will increase as the grade increases.

(2) With separate excitation at continuous current, armatures and fields, a considerably heavier train may be handled down hill than up hill and at a slightly greater speed. The percentage difference in the size of the train thus handled decreases as the grade increases.



Comparison Between Separate and Traction Motor Excitation

(3) With separate excitation, a train may be handled down grade at a considerably higher speed than this train can be hauled up the same grade, assuming that the safe operating speed is not exceeded. The percentage difference in these speeds decreases as the slope of the grade increases.

This study indicates that motor excitation may best be applied to a line with comparatively light grade, e.g., 1½ per cent and under. It will still be applicable with heavier grades if these grades are short and consequently little time is lost on account of slower speeds or if the

slower speeds obtained will not handicap the schedule speed desired.

Regeneration with separate excitation is particularly applicable to heavy grades, e.g., 2 per cent and over when the length of these grades is an appreciable part of the total length of the line. It is also preferable to use this system for lighter grades when it is necessary to take advantage of the highest speeds possible down grade.

Concerning reliability of operation, there will be little if any difference between the two systems, assuming that the same rugged type of equipment is used in each case and that the same method of compensation is used as has already been described.

It is evident that the additional expense of providing for regeneration is less with motor excitation than with separate excitation, since in the former case less additional equipment is required.

It is to be noted that the foregoing comparison covers the specific case of a two-speed, six-motor locomotive. The same general considerations would apply to a similar comparison for any two-speed locomotive. For locomotives with more than two motoring speeds or combinations there will be cases where motor excitation cannot be so readily applied on account of the limited speed range which can be obtained. This would be the case, for example, with a three-speed locomotive such as the Mexican locomotive. The logical regenerating combination in this case would be with one motor acting as an exciter for the other five motors in series. The speed range thus obtained would be quite low in comparison with the highest motoring speed, which is obtained with three parallel groups of two motors in series in each. Other combinations could be worked out for this type of locomotive, but with a reduction in braking torque which would, of course, be undesirable. To other types such as the C. M. & St. P. gearless passenger locomotive, motor excitation can be more readily applied. This locomotive has four motoring combinations, viz., with twelve, six, four and three motors in series across the line. Two regenerating combinations are obtained with eight regenerating motors in series and two parallel groups of four motors in series. Thus a better speed range regenerating is obtained than with the six-motor, three-speed locomotive cited above.

It is not within the scope of this paper to discuss all possible combinations to which motor excitation may be applied. From the foregoing discussion, however, the conclusion may be drawn that this type of regenerative braking may be readily applied to two-speed locomotives in general and in some cases to locomotives with a greater number of motoring combinations.

It has been attempted in the foregoing discussion to present the characteristics of certain types of regenerating systems which have been successfully applied to direct-current locomotives. In general, it may be stated that a system with a separate generator for excitation of the motor fields is to be preferred, as this gives the same motor combinations regenerating as motoring and furnishes the full torque of each motor for braking the train. However, since the motor excitation system can be provided with less additional expense, it is desirable to consider this method when the expense of the separate excitation system does not seem justifiable.

The purpose of this paper has been to present in a general way the principal characteristics of the regenerating systems of those direct current locomotive that are now running.

In any application before a choice of the braking system is made, a thorough study should be made of all the contributing factors.

B. & O. Starts Train Connection Bus Service in New York City

Train-side motor coach service to and from the heart of New York City will be inaugurated by the Baltimore & Ohio Railroad Company, when its new fleet of specially built parlor-coaches will be put in operation on Sunday, August 29. This use of motor coaches by the Baltimore & Ohio for the comfort and convenience of passengers to and from the business, shopping, hotel and theatre districts of New York City is the first of its kind to be undertaken by any railroad company, and marks a new era in the co-ordination of motor coach and railroad transportation.

Railroad passenger business, like other lines of business, has become keenly competitive, and it is pointed out that this rivalry among carriers for patronage, has contributed in producing better service and greater traveling conveniences. This and the natural evolution of transportation have resulted in such refinements as the club car, train secretary, valet, barber, maid, manicure—not to mention the fine dining cars and meals which have long been available—as part of the equipment and personnel of the premier trains of the country, such as the Capitol and National Limiteds. Consequently, it is believed that this unique plan, which the Baltimore & Ohio Company has hit upon as a solution of a big terminal problem, will be one of the greatest, if, indeed, not the greatest, single, progressive step in railroad passenger transportation in recent years.

By the operation of this fleet of motor coaches over convenient routes, with ticket offices, waiting rooms, baggage-checking and every other station facility and convenience at two well known and frequented points in uptown New York, the Baltimore & Ohio's passenger terminals in the metropolis are brought closer and made more accessible to its patrons. One of these new stations will be located in the Pershing Square Building, at 42nd Street and Park Avenue, the initial starting point of all coaches, the other, at the Waldorf Hotel, Fifth Avenue and 33rd-34th streets. Besides taking on and letting off passengers at these two uptown stations, the "Baltimore & Ohio Train Connection," as the new coach lines will be known, will make stops en route at other convenient points, uptown and also in the downtown section for this purpose.

Baltimore & Ohio passengers arriving at the Jersey Terminal will step from the train into one of the new, modern motor coaches, standing ready in the train shed, alongside the tracks. Passengers who have never visited New York City before will be afforded their first opportunity of completing their journey with an interesting panoramic view of New York's famous skyline, enjoyed even by the seasoned traveler.

On the other hand, Baltimore & Ohio passengers departing from New York, instead of having to walk far, go up or down stairways, wait in line to have tickets punched before passing through gates, etc., will step into the coaches at convenient points, with no trouble whatever and be landed alongside of their train in the Jersey Terminal. The new arrangement will also relieve passengers of anxiety about missing their train, which under the steadily increasing city traffic in New York becomes a more serious matter, as Baltimore & Ohio trains will wait until motor coaches arrive. For persons from the uptown section in the vicinity of Pershing Square at 42nd street and Park avenue, opposite Grand Central Station, and the Waldorf Hotel, as well as the Vanderbilt, McAlpin and Pennsylvania hotels, the Train Connection Coaches via the 23rd street route will afford a particularly

expeditious and comfortable trip, as it will take only a short time to get out of the congested trip.

Passengers will not have to leave the motor coaches from the time they enter them until arriving alongside of their train, remaining in their seats for the whole distance. Hand baggage will be taken care of by the coach attendant in a special compartment at the rear of the coach, thus relieving passengers of bothering with it. Upon arrival of the train it will be immediately transferred to their respective cars.

There will be no extra charge for the use of the "Train Connection" coaches. Purchasers of tickets over the Baltimore & Ohio from or to New York will pay nothing more than the regular railroad fare, the motor coach connection being taken care of by a special card for which no charge will be made.

The coaches will be operated over two routes between the new stations in the Pershing Square Building and the Waldorf Hotel and the train-side at the Jersey Terminal. They will be run on fixed scheduless, so arranged as to afford a convenient, dependable and economical service not otherwise obtainable, with practically no sacrifice of time.

One of the routes to be traversed will be for uptown travel only, and the other for both uptown and downtown travel. The one for uptown travel exclusively will be between Pershing Square Station at 42nd street and Park avenue and the Baltimore & Ohio trains, by way of Park avenue, west on 33rd street (east on 34th street) Seventh avenue and 23rd street, making stops in both directions at the following places: Vanderbilt Hotel, Park avenue and 34th street; Waldorf Hotel Station, Fifth avenue and 33rd-34th streets; McAlpin Hotel, Broadway at 33rd-34th streets; Pennsylvania Hotel, Seventh avenue at 32nd-33rd street and the Twenty-third street terminal of the Baltimore & Ohio.

The other route, for both uptown and downtown travel, will be between Pershing Square Station and Baltimore & Ohio trains, by way of Park avenue, Fourth avenue, Lafayette street, Chambers street, West street and Liberty street, with the following stopping points: Vanderbilt Hotel, Park avenue and 34th street; 14th street and Fourth avenue; Consolidated Ticket Office, Chambers street and Broadway, and the Liberty street terminal of the Baltimore & Ohio.

All coaches will start from the station at Pershing Square Building and passengers can leave that point via either route. Those Via Twenty-third street will stop at the Waldorf Hotel Station to pick up passengers.

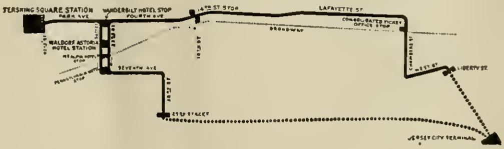
The motor coaches to be used in this train-side service are specially built for the Baltimore & Ohio Railroad for this particular purpose. They will be of the most modern and comfortable design, with individual seats for 23 passengers. A separate section in the rear of each coach will take care of hand baggage, with additional space on the top for use if necessary. Each coach will be operated by a chauffeur expert in traffic and there will be an additional uniformed attendant to look after the safety, comfort and convenience of passengers at all times. There will always be a sufficient number of coaches ready for each train connection in both directions.

The new stations at the Pershing Square Building and the Waldorf Hotel will be equipped with commodious and comfortable waiting rooms, ticket offices, information bureaus, parcel rooms, attendants for checking baggage, porters, and every other detail of service ordinarily found in railroad stations. Improvements have been made at the Jersey terminal to permit the handling of the coaches to the train-side. Special driveways for the coaches and special tracks for the trains have been provided.

Like all innovations of this character it takes time to realize their full value, but it is felt that once used, this unusual "automobile" service, from the very step of the train to the hotel door, as well as to the door of every other building along the two routes, in both directions, will prove of great advantage and convenience to many.

Newark, Elizabeth, N. J., Train Connection Motor Coach Service

Simultaneously with the introduction of the Baltimore & Ohio Train Connection motor coach service in New York City, the same kind of service will be inaugurated



Stations in New York City for B. & O. New Train Side Bus Service

by the Baltimore & Ohio Railroad between Elizabeth and Newark, New Jersey. Motor coaches will meet trains at Elizabeth, taking passengers into the heart of Newark and bringing passengers from Newark to Elizabeth to connect with trains there.

These Train Connection coaches will start from the Jersey Central Station, on Broad street, near Market, proceed north to the Public Service Station and the Robert Treat Hotel, turn around Park place to Broad street and thence direct to Elizabeth for connection with westbound Baltimore & Ohio trains.

Passengers for Newark will leave the train at Elizabeth and step into Baltimore & Ohio motor coaches waiting to take them immediately to Newark, where stops will be made at the Jersey Central Station, the Public Service Station and the Robert Treat Hotel.

The Baltimore & Ohio will have a ticket office and baggage checking facilities in the Jersey Central Station at Newark, and through tickets can be secured to and from that point at regular railroad fares with no charge for the coach service.

Permanent Paint for Iron Discovered

The annual loss to the world due to the rusting of iron runs into millions of dollars, and the problem of its prevention is being studied by scientists in all civilized countries. Zinc, tin, nickel, ordinary lead paint and many other things are useful preventives but they do not last and have to be applied more or less frequently.

A remarkable discovery is now announced by Dr. A. V Blom of Berne, Switzerland, who has made a new lead paint which affords complete and permanent protection to iron. This paint is of a very special character; it is made by melting lead in an electric furnace and blowing through it air and certain reducing gases, so that a dross or scale is produced which consists of colloidal or extremely finely divided lead dispersed in yellow lead oxide. When it is powdered and mixed with a specially prepared linseed oil and applied to an iron surface, very minute particles of lead separate out and gradually penetrate into the surface of the iron. The presence of the lead in the treated iron has been proved by photomicrographs and by chemical analysis. Iron objects painted with this new pigment have not shown any signs of rusting after prolonged exposure, or after being heated in steam. This discovery may lead to extremely important developments.

Value of the Steam Indicator

By W. E. Symons

In the July, 1925, issue of this paper there appeared an article in which the delayed use of the indicator was the means of locating and pointing the way to a correct solution of a very serious defect in the design of a locomotive.

Among those whose attention was drawn to this article and who have made inquiry for further information on the particular case and the subject in general, is a manufacturer of steam engine indicators. They are quite solicitous to know if the indicator cards were preserved and are now available.

The indicator cards in question were preserved with others in regard to more or less similar cases, although not available for immediate use.

Going over available papers in search for material to make response to these inquiries, the author finds an ample supply in proceedings of the Western Railway Club of October, 1905, which, with one additional example are herewith reproduced.

It was a defective steam pipe which led to the discovery of the original defects in the live steam passages of the cylinders of the locomotive. The original cards, Exhibit 3, "before and after" taken by the author will, no doubt, satisfy the most critical mind as to the cause of trouble with this engine. The proper remedial measures were applied and credit for which should be given to the indicator, for had it not been applied, the Lord only knows how much longer the company's officers would have blundered along in darkness, wasting the company's funds with a badly defective engine. That the two cards in question together with others shown are equally, if not in some respects more interesting.

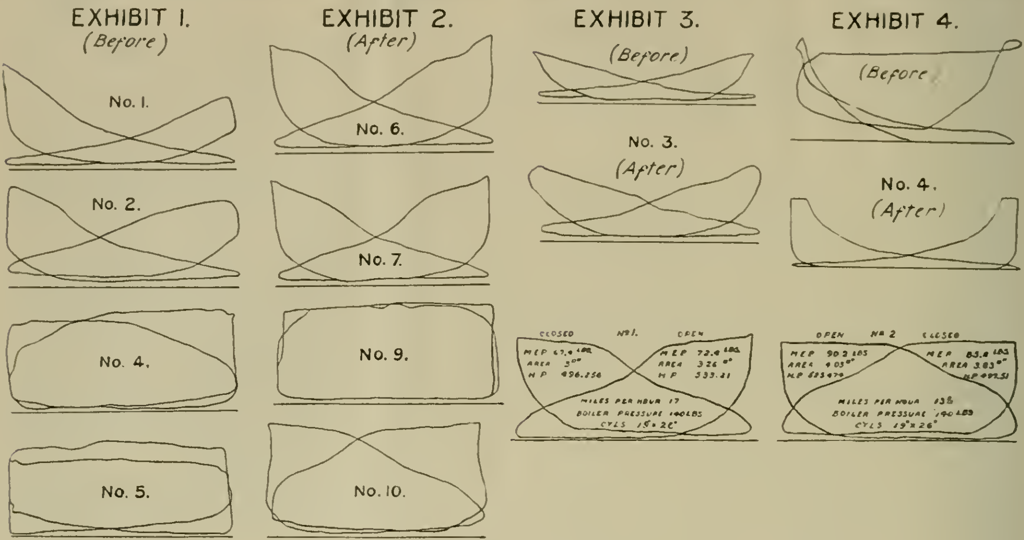
That there may be no confusion or mistake in study or comparisons the following identification may be helpful.

Exhibit No. 1, cards 1 to 5, and 6 to 10 were taken from an engine on the Mexican Central Railway.

Exhibit No. 3 shows two cards one taken while engine was equipped with contracted steam pipe and the others after defective pipe had been removed and replaced with one of proper dimensions. This was a small eight wheel or American type engine on a railway in the northwest.

Exhibit No. 4 shows cards taken from a Corliss engine in a saw mill in Arizona with a badly distorted valve motion. The top cards taken from the engine in its defective condition, while the bottom cards are from the same engine some 4 or 5 days later, after repairs and adjustments to the valve gear had been made.

Exhibit No. 5 shows cards taken from a passenger engine in heavy service on one of our transcontinental lines in the Rocky Mountain territory on grades up to and in excess of three per cent.



Steam Engine Indicator Cards

This engine was equipped with an adjustable or variable exhaust nozzle, whereby the engineer could at will change the area of the exhaust orifice or tip and consequently increase or decrease the back pressure on pistons and of course influence the potential capacity of the engine, amount of fuel consumed, and the general efficiency of the engine as a prime mover.

The medium through which all of the foregoing results were obtained was the indicator, and its value in these cases established.

In the case of the engine on Mexican Central Ry., this was one of an order of five up-to-date engines, but when placed in service it fell so far short of expectations as to call for an immediate investigation as to the cause or lack of steaming qualities, and use of excessive quantities of fuel, which rendered their continued use practically impossible.

After some considerable rather salty correspondence with the builders and various opinions by theoretic engineers and practical mechanics, setting and resetting valves, etc., the author applied an indicator, which resulted in discovery that the pistons were more than one inch too thin. This caused a useless waste of steam, on one trip of more than 50,000,000 cubic inches, and this of course

was emphasized by very expensive and inefficient operation.

The steam engine indicator told the story at once, the pistons were replaced by others of proper dimensions thus eliminating excessive clearance in the cylinders and the engines then proved satisfactory.

In the case of the Corliss engine, Exhibit No. 4, the trouble was caused by foreign matter being allowed to drift into and obstruct the operation of the valves, both steam and exhaust. In fact, the valve stems had been so twisted as to leave the live and exhaust steam passages open and in direct communication during a considerable distance of the stroke at one end with the results shown by the cards, while at the other end, the premature closure of exhaust valve caused excessive compression, each contributing to the wasteful inefficiency of the power plant as a whole.

The bottom cards taken from the same engine after repairs and proper adjustments of valve gear had been made show the difference between a monstrosity or impossible condition, and an economical highly efficient prime mover. In diagnosing this as in all the foregoing cases, the indicator made it possible to quickly determine the cause and apply proper remedial measures.

The cards shown in Exhibit No. 5 were taken from a passenger engine in heavy service in the Rocky Mountain district where grades of more than 3 per cent prevailed. This particular engine was just out of the shop after having received a general overhauling comparable to our present Class 3 repairs. Like most all engines then and now, however, the exhaust nozzle was of a size to produce sufficient draft to insure the engine steaming under adverse, or the poorest conditions, consequently, there was excessive back pressure on pistons all the time resulting in excessive fuel consumption and limiting the potential capacity of the machine. To overcome this feature a variable exhaust nozzle was applied whereby the engineer could at will change the size or area of the exhaust nozzle to suit operating conditions as to weight and speed of train, quality of coal, etc. This device not only made it possible to increase tonnage and speed of train but resulted in a saving in fuel of $800 to $1,000 per year with coal at $3.00 per ton, to which statement the indicator cards in Exhibit No. 5 will eloquently testify.

There are thousands of locomotives running today more or less crippled from excessive back pressure on pistons, that could easily be rendered more efficient, and many millions of dollars saved in fuel costs, by the use of the indicator, and then applying plain practical and inexpensive remedies, in the correction of such defects as are found to mitigate against the potential capacity of the complete unit.

Scheduling of Equipment Through Shops*

By H. C. Venter, Superintendent of Shops, Southern Pacific Company

About two years ago the Southern Pacific Company shop management began to formulate plans whereby they could not only be more certain of a constant output of locomotives and cars, but could regulate this output so that it would be evenly distributed over any given period.

Prior to that time there was no definite system in effect. Each department endeavored to route work through the shop to the limit of its capacity, and each department worked independently of all other departments.

This system was not satisfactory. It was impossible to know how the various forces working on the job were balanced. In some departments the work for a unit of equipment would be completed, while in other departments it would be constantly delayed. The defects in this system were particularly noticeable as applied to material. In many cases the necessity for certain material was not anticipated, with the result that it was not on hand when needed. If the required material was not carried in Store Stock, it was necessary to place orders on shop industries for its manufacture. This resulted in more or less confusion in the manufacturing shops, causing disruption of their regular program to furnish material on special orders.

To overcome these difficulties a simple but effective method of time scheduling equipment through the shops was considered which, when adopted, resulted in the maximum of performance at the minimum of cost.

The first step toward establishing this schedule system was to determine the minimum amount of time required to pass a locomotive or car through the shops for designated repairs. Primarily it became necessary to decide upon a key department or gang to which the work of all other departments could be coordinated. This "key" was decided to be the boiler shop for locomotives and the paint shop for cars.

* *A Paper Read Before the Pacific Railway Club*

Time schedules were then determined for the various classes of repairs as applied to the different classes of locomotives and cars. A schedule supervisor, detailed from the general foreman's office, divided locomotive and car repairs into from 20 to 30 sections, assigning each section to the department in which the work was to be performed. Sufficient time was allotted each department to perform the work, which they were required to pass on to the next department by a specified time. In this way all work would reach the erecting shop in orderly sequence on dates previously determined.

The shop foreman was thus relieved of responsibility for planning the work through the various departments and found more time for the supervision of his men.

Development of this plan has provided the schedule supervisor with complete data which enables him to set correct dates for all classes of repairs to equipment.

On large schedule boards placed in the various shops a color scheme of buttons is used to designate the various kinds of work as it passes through the shops. The men become interested in watching the movement of these buttons over the board and take a pride in seeing that the work progresses on schedule in their department. A distinctive button, known as the "Goat Plug," is shown on the board when work is delayed, indicating the particular shop responsible. The foreman of the department at fault naturally is interested in seeing the button against him removed as soon as possible, as it indicates to officials passing through the shops that his department is behind with its work.

The schedule board also enables the shop superintendent to locate stagnant conditions and immediately placed his finger on the department that is delaying the work.

To give an illustration of the operation of the schedule system, we will take the instance of an engine sent in from an outside division for repairs.

The master mechanic of the outside division fills in a form, known as 7004, showing the principal items of repairs required on the locomotive. He is placed in possession of this information through regular inspections, and can advise whether new cylinders, frames, driving wheel centers, etc., are required. This form is then sent to the General Shops in advance of the locomotive. Arrangements are made to get the necessary material assembled before the locomotive arrives at shop and enters upon its schedule.

When the locomotive arrives at the shop, the boiler inspector inspects the boiler and firebox and makes a report of all defects found, together with his recommendations as to what should be done to correct same. This report includes all I.C.C. inspection dates and other similar data. The machinist inspector also makes his inspection at this time and submits a report. These reports are then checked against the Master Mechanic's report and the class of repairs decided on.

Thus it is found that the locomotive we have taken for an example will require a new firebox in addition to general repairs to machinery. This is known as Class 2 repairs.

The tender is cut from the locomotive; the locomotive passes into the Erecting Shop and the tender passes into the Tender Repair Shop. Dates are then fixed for each item of repairs. Items 1 to 4 on schedule sheet cover the stripping of locomotive and delivery of parts to the various departments. The locomotive is then placed on a 45 day schedule. For example, say, it enters the shop on February 13th. Jacket and lagging are removed by February 16th. Boiler off frames February 19th.

Material requiring repairs is delivered to the various departments on February 20th. The Blacksmith Shop has from the 19th of February to the 9th of March to finish the frame work. The Machine Shop has from the 9th of March to the 22nd of March to finish the work assigned to it. The Erecting Shop has from the 22nd to the 26th of March to erect the frame work furnished by the other departments.

Shoes and wedges are laid off on March 26, machined in the Machine Shop on March 27th and erected on engine on April 1st.

Guides and rocker boxes are due out of Machine Shop March 22nd, and are erected on engine March 26th.

Cylinders and valve bushings due out of Machine Shop on March 22nd are put up on March 26th.

The boiler, due out of Boiler Shop on March 24th, is placed on frames on the 26th.

This schedule allows machinists two days to bolt boiler to saddle. Boiler fittings, due out of Machine Shop on the 26th are applied to boiler on the 30th and boiler work is completed on the 30th.

Spring rigging is due out of Blacksmith Shop on the 10th, out of Machine Shop on the 27th, and due up March 31st.

The hydrostatic test is made March 31st, and steam pipes and units are applied April 1st.

Shoes and wedges, due out of Machine Shop March 27th, are up April 1st.

Wheels and trucks, due out of Machine Shop March 31st, due up April 1st. Fire is up and steam test made on April 2nd.

Motion work, due out of Blacksmith Shop March 10th, out of Machine Shop March 31st, and due up April 2nd.

Valves are set and checked April 3rd.

Boiler mountings are due up April 3rd.

Pumps and reservoirs are due up April 3rd, cabs and running boards applied April 5th, and lagging and jacket due on April 5th.

Brake rigging is due from Blacksmith Shop March 12th, from Machine Shop April 1st and due up April 5th.

Pistons are due from Machine Shop March 31st and due up April 5th.

Main and side rods, due from Machine Shop April 3rd, are due up April 5th.

Pipe work and wiring are due up on April 6th.

Tender is completed on April 6th.

The engine goes on trial trip April 6th, and is O.K. and in service April 7th.

This is an example of a heavy class locomotive passing through shops for repairs. Our records show that previous to the adoption of the schedule system and working under old methods, this engine would have been in the shop a minimum of sixty days. We are now certain that when an engine enters the shop for repairs it will be out on the date predetermined when it is first placed on schedule.

Practically the same procedure is followed in the case of car equipment, except that car work is broken up into fewer items than is locomotive work.

During 1923 Sacramento General Shops turned out 78 Class 2 repairs at an average of 54 working days per engine. In 1924, under the schedule system, 92 Class 2 repairs were turned out at an average of 41 working days per engine. In 1925 we turned out 75 Class 2 repairs at an average of 42½ working days per engine. This included five Mallet engines. Schedules on other classes of repairs, ranging from Class 1 to Class 5, have been lessened in proportion.

The reduction in number of days locomotives are in shop naturally reduces the cost of making repairs. We have found it to represent a saving of from $2,000 to $3,000 per engine. During the year 1924, when not using the schedule system, 179 passenger cars, receiving general repairs were turned out at an average of 36 days per car. At the present time all classes of passenger cars are turned out at an average of 25 days per car.

When our schedule system was inaugurated it encountered more or less objection from the various supervisors in both departments. They felt it to be a reflection on their ability and feared that some of their responsibility was being encroached upon, but after the system had been thoroughly explained and had been in operation for several months, it won the support of the entire organization. The system at once indicated that many of the delays for which certain foremen had previously been held responsible were not originating in their department. The schedule board indicates to everyone at a glance just where any delay is actually occurring, and relieves foremen of many details with which they formerly had to contend. The time thus gained is used to advantage by each foreman in directing the activities of his men.

One of the advantages of scheduling locomotives and cars through the shop is that materials will come from the various shops in a continuous flow, making it unnecessary for any of the men or foremen to visit other departments in order to coordinate their work. If the schedule is followed properly, all materials will be delivered to the various departments in ample time for them to complete their work so that the engine may be placed in service on date scheduled.

The full cooperation of the Storekeeper is an important factor in the successful operation of the schedule system (and it can be said in passing that we have this cooperation at Sacramento), as he and his department form one of the important spokes in the wheel.

The fact that at Sacramento we have several manufacturing industries, such as iron, steel and brass foundries, etc., also works advantageously for the schedule system. These manufacturing plants were originally provided to offset delays due to the distance of our railroad from the usual sources of supply. Had these facilities not been

provided, long delays would constantly have resulted in obtaining materials from Eastern markets.

Oftentimes after a locomotive is stripped and parts are subjected to hammer test, flaws are found in frames, castings, wheel centers, etc., which could not have been discovered by ordinary inspection while the locomotive was in service. The need for such new castings could not therefore be anticipated without the carrying of a very large and expensive inventory covering all the many parts and materials which might be required. With our manufacturing facilities at hand, however, we are able to place orders for the required parts immediately, and have them completed and on hand as demanded by the requirements of the schedule.

Our manufacturing plants also enable us to utilize the large amount of scrap accumulated on the railroad, and which can be worked up at more of a profit than would be realized if the material were sold as scrap. Our foundries are particularly advantageous in the manufacture of cylinders and other large items for the marine equipment of the company, as there are no foundries on the Coast, except ours, sufficiently large to handle such castings.

The foregoing description of our process for the handling of engines and other equipments through the shops may seem to reflect an advantage to the railroad company alone in the time and money saved. But when it is considered that the shippers of the country's products and manufactured articles are so entirely dependent on the railroads for the movement of their goods, it will be seen that they too reap the advantage of having serviceable equipment on hand when it is needed for the peak movements of their products. During the peak seasons, when thousands of carloads of fruit and vegetables are routed eastward, every available locomotive and car is needed to handle the trains, and every piece of needed equipment held up in the shops for repairs may mean a direct loss to the shippers. Short delays may seem trifling in ordinary times, but during the season mentioned, even a few hours delay may mean thousands of dollars lost to the shippers. At such times the company's system of scheduling its equipment through the shops with a minimum of delay, means actual dollars and cents saved to the public.

We have found that our schedule system promotes efficiency, brings about greater economy in which both railroad and public share, and insures dependable service. These three items, to a greater degree than any other feature in railroad operation, denote real progress.

Freight Train Speed Greatly Increased

Among the most striking accomplishments of the railroads in recent years in improving transportation is the increase in the average speed of freight trains.

In 1925, the average speed of freight trains was 11.8 miles per hour, as compared with 10.3 miles per hour in 1920. This speed is not the actual running speed but includes all stops made for switching, for picking up and setting out cars, and so on.

The average speed of freight trains on the Class I railroads is shown in the accompanying table:

	Miles Per Hour
1920	10.3
1921	11.5
1922	11.1
1923	10.9
1924	11.5
1925	11.8

Due to the heavier average train load and the higher average train speed, the average freight train performed more service per hour in 1925 than ever before. The average train, each hour of its trip, performed a service equal to hauling 8,773 tons of freight for the distance of one mile. The corresponding figure in 1920 was 7,302 ton-miles. The service performed by the average freight train in an hour is shown below for the Class I lines:

	Tons of Freight Carried One Mile
1920	7,302
1921	7,506
1922	7,479
1923	7,770
1924	8,222
1925	8,773

Record Fuel Savings in Passenger Service

An outstanding record mawe by the railways in 1925 was in the use of the fuel used in passenger service. In 1920 it took 18.8 pounds of coal to move a passenger-train car one mile. In 1925 the amount of fuel required to do the same work had been reduced to 16.1 pounds, a saving of 14 per cent. The amount of fuel used by the Class I railroads in moving a passenger-train car one mile is shown below for the past six years:

	Pounds
1920	18.8
1921	17.7
1922	17.9
1923	18.1
1924	17.0
1925	16.1

The savings in passenger service in terms of money, resulting from increased efficiency in the use of fuel, have amounted to $41,730,000 during the past five years. In 1925 alone, the increased efficiency in the use of fuel resulted in a money saving of $14,000,000 compared with 1920.

The 1925 fuel use, compared with 1920, represented a saving of 2.7 pounds of coal for every mile a passenger-train car was hauled. On the basis of the 1925 traffic, this increased efficiency in the use of fuel saved 5,020,805 tons of coal. As the average cost of railway coal in 1925 was $2.72 per ton, this meant a money saving of $13,657,000. Details of the savings for the other individual years are given in the succeeding paragraphs. This data covers Class I lines.

The 1921 fuel use, compared with 1920, represented a saving of 1.1 pounds of coal for every mile a passenger-train car was hauled. On the basis of the 1921 traffic, this increased efficiency in the use of fuel saved 1,905,740 tons of coal. As the average cost of railway coal in 1921 was $4.10 per ton, this meant a money saving of $7,814,000.

The 1922 fuel use, compared with 1920, represented a saving of 0.9 pounds of coal for every mile a passenger-train car was hauled. On the basis of the 1922 traffic, this increased efficiency in the use of fuel saved 1,532,052 tons of coal. As the average cost of railway coal in 1922 was $3.94 per ton, this meant a money saving of $6,036,000.

The 1923 fuel use, compared with 1920, represented a saving of 0.7 pounds of coal for every mile a passenger-train car was hauled. On the basis of the 1923 traffic, this increased efficiency in the use of fuel saved 1,251,895 tons of coal. As the average cost of railway coal in 1923 was $3.45 per ton, this meant a money saving of $4,319,000.

The 1924 fuel use, compared with 1920, represented a saving of 1.8 pounds of coal for every mile a passenger-train car was hauled. On the basis of the 1924 traffic, this increased efficiecy in the use of fuel saved 3,268,485 tons of coal. As the average cost of railway coal in 1924 was $3.03 per ton, this meant a money saving of $9,904,000.

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Frozen Accounts or Idle Money

During the past year there has appeared in the columns ot this paper several articles on the subject of frozen accounts or idle money which aroused no little comment and some adverse criticism.

The articles in question were written by one of experience in all phases of the questions involved, and presented to our readers pursuant to the established policy of this paper to do all we can at all time to aid or improve the railway situation in general.

That there was at the time and is now great sums of railway money tied up in unnecessary material and supplies is well known to all those competent to judge, although certain lines have made material reductions in stocks on hand that amount in the aggregate to many millions of dollars.

At the time these articles appeared in RAILWAY & LOCOMOIVE ENGINEERING quite a few of those more or less affected thereby responded in a manner indicating their position, with comments on the general subject.

Some of those, whom it may be assumed were open to criticism in this matter were disposed to take umbrage at being so reminded. Others gave evidence of a more broad-minded, liberal spirit by acting on the tip or subgestions, instituted a good old fashioned house cleaning which resulted in saving great sums of money for their companies by releasing for use in other channels millions of dollars tied up in unnecessary frozen accounts.

In the last analysis, some one or some body of men must finally decide questions of quantity, quality and price of stores and thereby control the amount so invested by each carrier. Then, if from any cause, the stock on hand is excessive, some person or persons must decide as to the approximate amount of reductions which should and can safely be made. From this same source there should emanate some formulæ, rule standard or yardstick whereby overstocking in future may be avoided without endangering efficient and economic operation of the property. On writer has placed the excess stocks on hand at $158,000,000, and carrying charges on this excess stock at $39,000,000 or approximately 25 percent. This same authority shows the percent or ratio of stock on hand to operating expenses on 68 railways as varying from 5.88 percent to as high as 30.66 percent which wide range may and probably does reflect local or individual conditions rather than pointing to errors of omission or commission.

Under average normal conditions it would appear safe or fair to place the stock on hand at 10 percent of operating expenses, although on lines that construct new engines and cars to any extent, or are constructing new lines, this amount would of necessity be exceeded.

On one of our heavy coal carrying lines, where purchases and stores are in charge of a major officer who has not only made a scientific study of the subject but adheres to business method, the ratio is below 10 percent. In fact, in last reports it was only 9.05 percent, while on some eight or ten neighboring lines similarly situated the ratios run from 12 percent to as high as 30.66 percent.

Our class 1 railways purchased last year (1925) additional stocks to the amount of $1,3492,043,454 which sum could, of course, been considerably reduced by using up all surplus stock on hand before purchasing any more.

Just how many millions could have been saved to our carriers in this way it is not possible to say. It is safe and proper to state that the purchase price of stocks they have on hand upwards of three to five years and much of which will not in all probability ever be used, will alone run into a sum that would astound the executives if cast up before them.

Here is one of the worst leaks in expenses incident to railway operation and maintenance. One that would yield the greatest returns if subjected to the same degree of good business judgment that actually exists in other branches of the carriers' business.

It has been truly said of Alexander the Great, that, when he sat down and wept that there were "no more worlds to conquer," he had only just scratched a little around the habitations of man. It may also be said of ourselves that as railway officers and experts, we sometimes strain our eyes looking for nickels while actually stumbling over five dollar bills.

Surely since the days of Caesar, men have seen much of the things they want to see.

Automatic Train Stopping and Controlling

The present situation in the matter of automatic train stopping and controlling is complex to say the least. The order has been issued and confirmed by the Interstate Commerce Commission that certain railroads shall equip certain portions of their tracks with an apparatus that will either control the speed or stop the train, or do both if the engineer disregards signals. At the hearing on the subject evidence was submitted by the railroads to the effect that the automatic train control was not yet in a sufficiently advanced state of development to warrant an application on an extensive scale, and that in any event the money required for such an application could be spent to much better advantage in installing automatic signals on unprotected track.

The manufacturers of automatic stops and control, met this by the assertion that they were ready to accom-

plish anything that the most rigid specifications might require. And the Commission stood pat on their order in all substantial particulars which is a practical endorsement of the control and stop companies contention that apparatus is available that will operate successfully.

It is interesting to note that the operation of these devices depend upon the brakes. This particular mechanism has reached a degree of perfection that will permit it to be operated automatically with all the skill and delicacy that a trained engineer can put into it.

The original idea was that of an automatic stop only. An emergency application of the brakes, including also a shutting off of steam at the throttle of the locomotive, and of bringing the train to a stop in the shortest possible distance and time; and this is the position still occupied by some who have given the subject a good deal of thought.

But this idea changed and it was found that it was necessary to modify the train control apparatus so as to avoid the danger of making an emergency application of the brakes at low speeds. This, at once, added to the complications and cost of the apparatus which should be able to act with sufficient intelligence to make an emergency application at high speeds and avoid doing so when the speed was low.

It has been shown that the automatic train control and stop is not a matter of interest to the signal and electrical engineer alone, but is one of vital importance to the mechanical department and especially that section of it in charge of the brakes. For the most important function after the electrical control has been developed is that performed by the brakes, and unless they are in such shape as to act properly any expenditure for automatic control would be simply money thrown away.

The Steam Engine Indicator

Elsewhere in these columns will be found an article on the value of the steam engine indicator with a series of diagrams or cards taken from engines that will no doubt be of interest to all students of this phase of steam engineering. In all our engineering experience, particularly in the use of the indicator, we have never seen a case of as badly a distorted valve gear than what is clearly shown in the cards taken from the Atlas-Corliss engine referred to in the article. There are some railroad men and others, who claim that the work done by the indicator is not reliable. From a large number of tests made both in stationary and locomotive practice, the indicator has been found to be absolutely correct and reliable in the measurement of the steam distribution in the cylinders, and the accuracy of its indications should be unquestioned.

In the instance cited, it remained for a less pretentious practical engineer to apply the indicator, take a photograph as it were of the sequence of events in the cylinder, apply simple, effective remedies and thus transform an impossible, wasteful monstrosity into an economical and efficient prime mover.

The diagrams accompanying the article were taken some years ago and we would not feel safe in suggesting that there are other cases quite as bad today. We have no hesitancy, however, in saying that from an engineering or financial standpoint the field for the application and use of the indicator is as broad and inviting now as it was when these cards were taken. In the item of excessive back pressure on pistons of locomotives alone, the intelligent use of the indicator and by profiting from the lessons thus learned millions could be saved in fuel expense, while the increased capacity of the engines would be difficult to measure in dollars and cents.

B. & O. Train Side Bus Service

A highly interesting development in railroad passenger transportation will be inaugurated on September 1, when the Baltimore & Ohio begins the operation of buses from 42nd Street and other points in New York City to the side of its trains in the Jersey City Terminal of the Central Railroad of New Jersey.

The B. & O. had built up a large passenger business into New York and with the expiration of its contract for the use of the Pennsylvania Station in the city, it was compelled to develop some plan to take care of this business. The result has been the train side bus service which is described elsewhere in these columns.

The plan developed by the B. & O. will be carefully watched by all railway officers, as it may give rise to an entirely new and supplementary service to be rendered by railroad companies and at the same time may contain the solution of many passenger and freight problems in congested areas and terminals.

Handling Suburban Traffic Here and Abroad

To the Editor:

The task of handling suburban traffic has been one of the outstanding problems of railroading during the past twenty-five years. There are a number of reasons for this, chief among them being the facts that the movement of this traffic is in and out of costly terminals while the traffic itself is not highly remunerative. Public criticism of the service rendered has not added to the attractions of providing it, and the exactions of local authorities have further increased the burdens of the railways involved.

When the provision of a local passenger service involved nothing more than the use of obsolete motive power and rolling stock on easy schedules and over uncrowded divisions, the problem was simple and taken as a matter of course. When, however, the demand arose for speedy and highly-specialized service to the "classy" suburbs with which we are familiar today, the problem took on a serious aspect and presented difficulties theretofore unknown.

Of course, the well-to-do classes use autos to a great extent. On the other hand, the advent of winter—or even of a period of inclement weather at other seasons—throws an enormous burden upon railways that are not ordinarily favored with a rush of short haul traffic. The ensuing confusion is not pleasant to contemplate!

Those of us who recall the Grand Central Station of an earlier day in New York will remember the processes by which it was overwhelmed. Its desperate and unavailing efforts to "serve two masters" ended as might have been expected and culminated in the substitution of the present "Terminal." Suburban traffic swamped the old station and will do likewise for the terminal unless something is done meanwhile. The same fate awaits many of the famous stations in the country, notwithstanding all the work done by autos, public and private. Sagacious engineers have understood this for a long time. The chief obstacle to progress is not—as some might suppose—expense, but municipal jealousy.

That similar conditions do not exist in a city so large as London is due, I believe, to the fact that traffic is not drawn to a focal point. There are some half a dozen large termini in the British metropolis, assisted by nearly as many more of smaller size and less importance. As a consequence, arriving throngs are scattered, and departing crowds are compelled to leave in relatively small groups and from different parts of town. There is no grand rush for one place!

Certain of the London termini cater to the working

classes and to others who may require to arrive and depart at fixed times, and who appear regularly in considerable numbers. The purposes of the present paper will be served better, however, by reference to the excellent service to be had to and from Paddington.

What we would call the "suburban district" on the Great Western Railway extends out as far as Reading, which is 36 miles from Paddington and is regularly reached in 40 minutes by trains of a local express character. As the engines which make this service possible are of more than ordinary interest, a few words about them may be pertinent at this time.

These engines are of the side-tank type with rear bunker, and have the 4-4-2 wheel arrangement. The first of them was built in 1905 and was based upon a 4-4-0 design of the preceding year, though equipped with a smaller boiler and other necessary modifications. The cylinders are 18 x 30 inches, the driving wheels are 80 inches in diameter, the tank capacity is 2,000 (Imperial) gallons, working pressure of boiler 200 lbs. and tractive effort 20,530 lbs.

It will be seen that the long piston stroke is incorporated in this design, together with large driving wheels to insure smooth running at high speed. The latter is an important item on a line operating so many fast trains as the G. W. R.

Of course, trains making all local stops do not afford such speedy service as that already mentioned, but the schedules compare very favorably with anything that we have to offer in America.

With reference to heavy traffic moving at moderate rates of speed: It may be of interest to note that engines of the Mogul and even of the Consoliddation types are used! As employed in passenger service, both types have 68-inch drivers—large enough for a fair rate of speed and small enough to insure quick starts and recovery from slowdowns. Though these types are not used in suburban service, they are mentioned here as the "power" frequently seen on short-distance semi-express trains.

The G. W. R. also has an assortment of old inside-connected (i.e., inside cylinder) 4-4-0 engines which handle light express trains and important short-run business. They are useful also on "cross-country" lines not at present strong enough to permit the employment of anything heavier.

In the United States one frequently sees heavy ten-wheel and even Pacific type engines on local or suburban runs; the cars used being rather heavy and the grades in some cases severe. Moreover, the supply of old 4-4-0 engines is being reduced very rapidly in this country due to the fact that the types is not being built these days.

The tank engine never has been popular in America, and it may be doubted whether it could serve any useful purpose here now. Certainly, the cost of building tank engines powerful enough to deal with many of the suburban trains at present operated would be far in excess of any possible advantage. And the foolish policy of some British railways in building clumsy big tank engines with a tiny grate area and a very inferior steaming capacity is not likely to encourage imitation over here. The tank engine enthusiasts of a former day have bequeathed a load of "lemons" to their successors of the present age.

On the other hand, the tank engine is kept in its proper place on the G. W. R.; that is to say, it is not employed in classes of service for which it is manifestly inadequate and inappropriate.

In England, as in America, a certain amount of suburban business is taken care of by the multiple-unit system of electric traction. There, as here, the matter is decided by practical considerations; in other words, the great capital outlay incident to electrification is not made except after rigid investigation. British railways cannot be stampeded on this question, and are—metaphorically, at least—"from Missouri."

In the "Old Country" they find some interesting methods of utilizing "old power." I am reminded, in particular, of some 0-6-0 "goods" engines which, by suitable extensions of the frames and the provision of a Bissel truck at front end and a radial truck at rear end, became very serviceable tank engines of the 2-6-2 type. Of course, the tenders were taken off, and side tanks substituted. I believe they are running this in the Birmingham district.

Reduced to its simplest terms, the suburban traffic problem embraces the principle of providing a reasonably satisfactory servise at a minimum cost. From the data at my disposal, I conclude that this result is easier of attainment in Britain than in America; chiefly because the

Suburban Passenger Train on the Great Western Railway of England

use of a cheaper grade of equipment is feasible in the former country. Certainly, the cost of the motive power and rolling stock used in the suburban service of some American railways is far in excess of the value of the business.

The photograph presented herewith is of interest as showing a British suburban train of the better class. The engine in one of the 4-4-2 tank type already described, and the "carriages" are "bogie stock." Though going only as far as Slough, the engine carries the marker lamps of an express—which indicates that the inhabitants of that town get good service! Due to the fact that the side-tanks partly mask the drivers, the latter appear smaller than the stated diameter. They are, nevertheless, 80 inches in diameter.

ARTHUR CURRAN.

New Cars for New York Central

New standards of safety and luxury in railroad coach travel are set in the 159 all-steel coaches and combination coach and baggage cars which the New York Central Lines has placed in service. The first of the coaches delivered are to be placed on the Empire State Express, the New York Central's fast train between New York and Buffalo. The coaches, perhaps the finest cars ever offered for the accommodation of non-Pullman passengers, will cost five million dollars.

The New York Central will use 100 of these coaches, while twenty will go to the Big Four; and fifteen each to the Pittsburgh & Lake Erie and Michigan Central. Of the combination baggage-and-coach, the New York Central will make use of four, the Big Four of three and the Michigan Central of two. These cars, built entirely of steel, cost about $29,000 each. They are 70 feet long and have a seating capacity of eighty-five passengers.

The Mechanical Construction of the Electric Locomotive

Some Details of the Design Used on the Virginian

The undertaking started by the Virginian Railway Company in 1923 to electrify 134 miles of its main line extending from Mullens, West Virginia, to Roanoke, Virginia, brought with it a problem in heavy traction never before attempted, for this road has long been noted for heavy rolling stock, large trains and high operating efficiency.

The Virginian Railway is preeminently a coal-carrying road, having a heavy eastbound traffic, a large majority of which is coal from the rich New River and Pocahontas coal fields near the western terminus.

The road profile shows that between the coal-receiving yards at Elmore and Norfolk the heavy grades, reaching a maximum of 2 per cent, are confined to the section between Elmore and Roanoke, and it is on this section also that the curves are severe, reaching a maximum of 12 degrees. The capacity of the section between Elmore and Roanoke is in reality the capacity of the entire system and for this reason the railroad has always faced the problem of designing very heavy motive power, leading all other roads for size and hauling capacity of their locomotives, the electric locomotive being no exception. The hauling capacity rating of the electric locomotive at 30 per cent maximum adhesion requires 900,000 lbs. of adhesive weight for the necessary 270,000 lbs. tractive effort.

The electric locomotive was briefly described in the June, 1925, issue of *Railway and Locomotive Engineering* and some details of its mechanical construction will be of interest.

Wheel Arrangement

The problem of distributing 900,000 lbs. of adhesive weight, and at the same time to provide a flexible wheel arrangement that would successfully negotiate the road curves both in hauling at the front and pushing at the rear of the train, brought out the fact that the 12 pairs of driving wheels must be divided into three sections, each section provided with a two-wheel engine and a two-wheel trailing truck and, therefore, the complete locomotive is known as the 282-282-282-E class, the letter "E" standing for "electric."

Spring Rigging and Equalization

The spring-supported loads are carried on a three-point equalizing system; one pair of drivers being cross-equalized with one truck forming the single point, and three pairs of drivers equalized with the opposite truck forming the other two points. This arrangement of the equalizing system gives a greater reaction against the rolling of the spring-supported loads than a symmetrical arrangement with two pairs of drivers in the cross-equalized and two pairs in the non-cross-equalized system.

The semi-elliptic springs have been designed for manufacturing from the flat bar and a reduction of scale lamination, due to one heat only in the manufacturing process, is thus obtained.

The reverse camber, or deflection, in the spring plate when the load is applied provides a very compact and satisfactory arrangement.

Guiding Trucks and Curving Characteristics

The unusual truck-duty required for the proper guiding effort has been taken care of by the introduction of a combination of hanger links and constant resistance rockers; the hanger links producing lateral resistance during the first part of the bolster travel, and the constant resistance rockers producing lateral resistance during the latter part of the bolster travel. The guiding characteristics with this combination show a low percentage of truck bolster load for the initial restraint against the bolster travel, this percentage increasing rapidly during the first part and reaching its maximum at about one half the bolster travel when resistance is transferred from the hanger links to the constant resistance rockers. The unique construction offered by this combination besides giving very satisfactory guiding characteristics, protects the wheel hubs against the extreme wear usual with high initial resistance rockers.

Virginian Electric Locomotive Built by the Westinghouse Electric Mfg. Co., and the American Locomotive Company

Motor Drive

Each cab unit is provided with two alternating current motors located between the driving and truck wheels at each end of each cab unit. Six motors per locomotive are used with a total horsepower rating of 7125. The motors are geared to a jackshaft with a gear ratio of 4.76 and in turn connected to the driving wheels by rods working on crank pins in the jackshaft disc and wheel hubs.

Frames and Crossties

The design of the main frames follows very closely the usual steam locomotive practice, except at the ends, where the jackshaft is secured in its pedestal. Each frame is

42 ft. 6 in. long and weighs completely finished without pedestal caps 18,450 lbs. Six frames are required for each locomotive.

The frame crossties form an important part in the electric locomotive design, not only for their value in bracing the structure and providing supports for the electrical apparatus, but for the resistance which they offer to deformation of the frame when the locomotive is lifted, or jacked at the ends. For this purpose one continuous casting extends between the motor supports.

The electrical equipment is protected by a sheet steel cab the whole length of the locomotive. The cab is arranged with an engineer's compartment at each end, partitioned from the main portion of the cab and provided with connecting doors, and the interior lagged with cork.

The roof of the cab is designed to allow the heavy electrical parts to be installed through hatchways to which water-tight covers are fitted.

Windows and louvres are located to secure the best arrangement for light and ventilation for the electrical parts, which are located along the longitudinal center of the locomotive.

Frames and Crossties of Virginia Electric Locomotive Built by the American Locomotive Company

The Service Performed by Our Railways

The Amount of Work or Service They Render as an Equivalent to Certain Unit Cost of Operation

By Lee G. Lauck, Union Trust Company, Cleveland, Ohio

It is safe to predict with reasonable assurance of being correct, that the average layman, etc., who reads or has been told of the magnificent accomplishments of our transportation systems has never stopped to think of the magnitude of the service which they have placed at his disposal.

Our railways are one of the largest concentrated industrial concerns in the country, with a value much greater than any single manufacturing industry. The capital invested in them is estimated to represent 10 per cent of the total wealth of the country. They manufacure passenger-miles and ton-miles, and retail and wholesale this transportation to the public in precisely the same way as any other manufacturer produces and sells his products to customers. When a passenger purchases a ticket, the railways, in effect, sell him so many passenger-miles of transportation. If the distance he is traveling is 200 miles, he purchases 200 passenger-miles of transportation. The total passenger-miles are therefore arrived at by multiplying the number of passengers carried by the number of miles conveyed, and during the year 1925 the American public purchased 35,963,894,000 passenger-miles.

In the case of freight, when ten tons of merchandise are sent from New York to Chicago, a distance of approximately 960 miles, the payment of the freight charges is equivalent to the purchase of 9,600 ton-miles of service. Ton-miles are the units of measuring up railway freight operation, and are arrived at by multiplying the weight of commodities conveyed by the distance carried. During the year just passed our railways sold 414,118,835,000 revenue ton-miles of freight service to the shippers.

For the year ended December 31, 1925, the railways sold these services to customers at the rate of 2.938 cents per passenger-mile and 1.099 cents per ton-mile. The former is scarcely more than the cost of a daily newspaper. In other words, for a trifle less than three cents the railroads carried a passenger and his baggage (where the weight is 150 pounds or less) one mile, and in addition approximately 9,000 pounds of vehicle to seat him. For only one and one-tenth cents they transported a ton of freight one mile and also hauled nearly 1,500 tons of dead weight to furnish the service.

Since 1913 freight rates have advanced a little over half of the increase in the cost of engines, cars, and other principal items of railroad expense, while the advance in passenger fares is only approximately half as much as the increase in the cost of these same items of expense. During 1913, the railways received 0.719 cent for hauling a ton of freight one mile; for transporting a passenger one mile the rate was 2.002 cents. For the year ended December 31, 1925, which period covers the latest available figures, these rates were 1.099 cents and 2.938 cents respectively. The 1925 freight rate represents a reduction of 13 per cent under 1921 and for passenger fares the percentage of reduction is about 4.9 per cent. Few persons have any conception of the extent to which freight rates have been reduced since the beginning of 1921. The savings to the shipping public from reduced rates aggregated $1,611,000,000 during the years 1922, 1923 and 1924. This is the total amount which shippers would have paid for transportation service in those years, over and above what they did pay, had the rates remained at the peak of 1921.

Thus the economies in operation have not accrued wholly to the railways themselves, for a large part of the benefit derived from reductions in operating expenses has

been passed on to the shipping public in the form of reduced freight charges

In order to earn enough gross revenues to purchase an ordinary cross tie the railways are required to haul one ton of freight 85 miles; for a hand lantern 120 miles; for a coal scoop 139 miles; a keg of railway spikes 546 miles; a box car 193,812 miles; and a freight caboose, 265,604 miles. To pay for a day of track labor it is necessary to haul one ton of freight 256 miles. For a day's wages of a freight train crew 4,040 miles. For a day's wages of a machinist 535 miles. To buy an ordinary day coach for passenger service the railways are required to transport a passenger 786.250 miles; and to supply a dining car one passenger has to be carried 1,597,142 miles.

Notwithstanding this situation our railways maintain the lowest rates, with a very low capitalization per mile, and at the same time pay wages that place the American railway employee on a plane which might be termed the aristocrat of the world's railway workers.

Same Principles are Applied to Producing Transportation as Are Used in Other Industries

The same principle which governs the successful manufacture of every day articles of life, such as clothes, shoes, etc., governs the manufacture of transportation, consequently it follows that transportation as manufactured by the railways is no exception to the rule and its price must be regulated by the cost to produce it. The cost of producing passenger-miles and ton-miles is made up by working expenses, taxes and the interest on capital invested. During the year just passed our railways paid approximately $1,000,000 per day in taxcs, at the rate of more than $363,000,000 per year. During this same period 63 per cent of the working expenses of the railways were represented by wages paid employees. The average compensation paid to each employee was $1,630, consequently it was necessary for the railways to haul one ton of freight 148,317 miles, or nearly six times the distance around the world, in order to earn a sum sufficient to pay the average yearly rate of pay to one employee. The average number of persons employed by the railways during 1925 was 1,769,099, so that they were compelled to show a performance of 262,387,456,383 ton-miles before they could meet their wages bill.

The work performed by the railways during 1925 involved 456,264,967,000 ton-miles, or approximately 8,774,326,288 ton-miles per week. This weekly ton-mile performance is equivalent to moving one ton over 94 times the distance from the earth to the sun, or moving an average train of 42 cars 309 times around the world.

Railways Are Large Purchasers of Supplies

In addition it must be emphasized that our railways are large purchasers of the products of American industry, in many cases the largest single group of purchasers. In 1925 they used over 28 per cent of the bituminous coal mined, about 6½ per cent of all the anthracite coal produced, 25 per cent of the total steel output, and about 23½ per cent of the total lumber production. In addition large quantities of metals, chiefly aluminum, lead, zinc, and tinplate were purchased directly by the railways in amounts averaging about one per cent of the total output, and it is also clear that the railways played an important part in the cement and copper businesses. Because of their tremendous volume, these aggregate purchases of the railways exercise a wholesome and stabilizing effect on the market.

While no one factor completely measures the efficiency of railway performance, certain ratios and averages are commonly regarded as significant indications.

The table below presents nine performance ratios for the years 1925 and 1924, and the results for 1925 in each case were the best on record for all time:

Performance Ratios

Class I roads

	Years ended 1925	1924
Freight Service:		
Freight car-miles per day	28.3	26.8
Net tons per train...............	744	715
Gross tons per train (excl. loco. and tender)	1,670	1,588
Freight cars per train............	43.8	41.7
Freight train speed (miles per hour)	11.8	11.5
Net ton-miles per train hour......	8,773	8,222
Gross ton-miles per train hour (excl. loco. and tender)........	19,679	18,257
Fuel consumption per 1,000 gross ton-miles (excl. loco. and tender) (pounds)	159	170
Passenger Service:		
Fuel consumption per passenger train car-mile (pounds)........	16.1	17.0

These ratios and averages point to the year 1925 as productive of perhaps the most efficient railway performance on record. Certainly the results were the best for any year of the past six, or since the beginning of 1920.

The freight car miles per day in 1925 were greater than in any previous year. The same was true of gross and net tons per train, number of freight cars per train, average freight train speed, gross and net ton-miles per train hour, and fuel consumption per unit in both freight and passenger service.

With regard to net ton-miles per car day, the year 1925 stood third to 1923 and 1920; in freight locomotive-miles per day, it stood third to 1920 and 1923; in passenger locomotive miles per locomotive day, the average for 1925 was second only to 1920. Only in the factor of the net tons per loaded car did the year 1925 show to disadvantage, its average being the same as in 1924, only one-tenth of one ton greater than in 1922, and lower than in any of the other years.

The most marked advances in 1925 were in the conservation of fuel, in tons per train, and in ton-miles per train hour. The result of the improvement in fuel consumption was most noteworthy. Based on the volume of traffic hauled by the railways in 1925, the actual saving in tons of fuel consumed, due solely to better use of fuel, amounted to 24,467,115 tons compared with 1920, and 7,302,797 tons compared with 1924. The value of this tonnage, at the prevailing average price of 1925, was $73,401,000 for the savings under 1920, and $21,908,000 for the savings under 1924. These savings were due entirely to increased efficiency in use. A study of these ratios and averages clearly indicates that the year 1925 was a record one for all times in operating efficiency.

Car Loadings Heavy

The total car loadings during the year ended December 31, 1925, were 51,177,962, equivalent to a weekly average of 984,192, or about 140,214 cars loaded per day. When we stop to consider these figures we only begin to realize that the American railway industry, for its size, and considering the large number of companies operating it, is the soundes and strongest business in the world. Without it life itself, except of the simplest sort, would be almost impossible. It penetrates into the remotest sections of the country and furnishes a service that is entirely dependable and adopted to our industrial life, and while there may be some mistakes to answer for it has created the most effective, useful, and by far the cheapest system of land transportation in the world.

The Transmission of Power on Oil-Electric Locomotives*

By Alphonse I. Lipetz, Consulting Engineer, American Locomotive Co.

The steam engine is a very flexible machine, making the steam locomotive a wonderfully adaptable and convenient means for railroad traction, while the Diesel engine is a most inflexible prime mover. As is well known, the Diesel engine is a constant-torque prime mover and the torque cannot be appreciably increased; neither can the engine start under load. This either makes direct coupling of driving wheels with the engine brake shaft impossible, or requires special devices in order to overcome the above mentioned handicaps of the Diesel engine. In the present article we shall only consider the various transmission systems employed in oil-engine locomotives, taking them up in the chronological order of their appearance in the art.

Class A comprises full power elastic fluid transmissions in which the total output of the oil engine is transferred into elastic-fluid energy, which is in turn utilized for the propulsion of the locomotive. The efficiency of such a transmission is the product of two separate efficiencies of the generation and utilization of energy. Various types of electric, hydraulic, pneumatic, compressed-steam, aero-steam, and compressed exhaust gas transmissions are described.

Class B consists of differential elastic fluid transmissions in which the power from the oil engine is transferred directly to the driving wheels at top speeds of the locomotive with a very high efficiency, and partly directly and partly indirectly at all intermediate speeds. The theory of such transmissions is expounded and formulas for torques, speeds, and efficiencies are derived. Examples of electric, hydraulic and pneumatic transmissions of this type are described and results so far obtained are given.

Class C pertains to mechanical (gear clutch) and direct transmission.

Power Transmission

Owing to the inflexibility of the Diesel engine the most natural thing to do is to use some sort of flexible power transmission in which a new intermediate energy is generated (electricity, hydraulic pressure, etc.), and immediately expended thus permitting a variation of torque and speed at will. Such a system requires in addition to the full power oil engine two more full power machines—a generator, pump or compressor, as the case may be, and a corresponding electric hydraulic or pneumatic motor. Assuming that a direct transmission of power by mechanical means is not possible the full-energy power transmission seems to be the only feasible solution. However, in speaking of the inflexibility of the oil engine we must not forget that the latter is not absolutely, but only relatively, inflexible, and that it can be regulated within certain limits—about 15 per cent above normal and about 75 per cent below normal. Consequently there would be a certain range within which a direct mechanical transmission of power would seem possible. Therefore there is a certain class of power transmissions in which the power is transmitted partly mechanically and partly through an auxiliary medium (electricity, oil, etc.). These transmissions have the advantage of using smaller auxiliary generators and motors and giving higher efficiencies within the range where the mechanical transmission of power is mostly used.

Further attempts have been made to make the oil engine more flexible in order to permit the use of direct mechanical transmissions. While such attempts have not yet passed the stage of preliminary trials, nevertheless they merit the most serious consideration as they may lead to the most desirable and most promising solution.

Thus we have three classes of power transmission for oil engine locomotive: A—Full power elastic-fluid transmissions; B—Differential elastic-fluid transmissions; C—Mechanical and direct transmissions.

1. Electric Transmission

The electric transmission is, of course, the most orthodox, the most thoroughly studied, the best worked out in all details, and the readiest to use. The idea is not new, as all component parts have been known for a long time and have proved separately their reliability during many years of service. A complete design of a main line locomotive was worked out by the Kelomna Works in Russia as far back as 1909. The Kelomna Works were at that time very active in building marine reversible Diesel engines for motorships on the Volga River, and being at the same time important locomotive builders they naturally became interested in the Diesel locomotives. The design, however, when fully completed did not encourage them or the Russian Railways to build a locomotive because of the excessive weight and cost. Several similar designs were worked out independently by other locomotive and Diesel engine builders in Russia during the period of 1910 to 1914, but none of them ever materialized. Nor were Diesel-electric locomotives built at that time anywhere else.

Electric transmissions, though, are widely used in railway motor cars with gasoline engines up to 150 hp. and running at from 1,000 to 1,500 r.p.m., both in this country and in Europe; but as we are not concerned here with gasoline locomotives, these motor cars will not be discussed. As regards Diesel-electric cars and locomotives, the following type were later built and tested.

The first combination of a heavy-oil engine and an electric transmission is found in a Diesel-electric motor car built in 1913 by the Swedish General Electric Company (Almanna Svenska Elektriska Aktiebolaget) in conjunction with the Diesel Engine Company (Aktiebolaget Atlas Diesel). Later the two firms organized a new company, the Diesel Electric Car Company (Diesel Elektriska Vogn Aktiebolaget), known as DEVA, and since 1913 about thirty cars have been built for Sweden, Denmark, France, and Tunis. They were built of various sizes—from 60 to 120 hp. as motor cars with compartments for passengers and for mail and baggage, and from 150 to 300 hp. as locomotives with compartments for mail and baggage only.

In all these cars the Diesel engine is of the Swedish "Polar" type. It is a four-cycle single-acting engine with air-blast injection, developing at 500 to 600 r.p.m. 15, 20, 25, and 30 hp. per cylinder, making thus 4, 6, 8, and 12 cylinders for the above-mentioned outputs. Except the 60- and 90-hp. engines, which have one row of vertical cylinders, all other engines are of the V-type, in which two cylinders in each transverse row drive one common crank. The electric generator is in line with the engine and is connected with it by a flexible coupling. The generator is of the eight-pole shunt-wound type, provided with a separate series winding which is used for starting the oil engine by driving the generator as a motor from a storage battery for a short time (1 to 1½ sec.).

* A paper presented to the American Society of Mechanical Engineers.

Except the 60-hp. car of the 2-2-0 type, which has only one motor, all other cars have two motors with a 2-4-0 wheel arrangement for 150-hp. and a 2-2 + 2-2 one for all other sizes.

Very soon after the appearance of the DEVA motor cars, several Diesel-electric motor cars were built for the Saxon and Prussian Railways by Sulzer Bros. in Winterthur, Switzerland, jointly with Brown, Boveri & Co. in Mannheim, Germany. They were first placed in service in 1915. The prime mover was a six-cylinder, V-type, four-cycle, air-injection Diesel engine which developed 200 b.hp. at 440 r.p.m. A direct-current, 140-kw., 300-volt, eight-pole generator capable of a 190-kw. output for one hour was directly connected to the engine brake shaft. A separate 7.5-kw. exciter supplied also current for a fan and for charging a 95-ampere-hour storage battery. The latter was provided for starting the Diesel engine by reversing the generator for a short time and operating it as a motor. Two six-pole series electric motors were set on a jackshaft mounted on the rear four-wheel truck and connected with both driving axles by means of connecting rods. Each motor was rated at 80 hp., and the output could be doubled for a period of one hour. For speed control a modification of Ward Leonard system was used, which consisted of varying the excitation of the generator and reversing the flow of current through the armature of the motors.

At the end of 1923, a 300-hp. 0-4-4-0 Diesel-electric locomotive was placed in railroad service in this country. The locomotive was built jointly by the General Electric Company and by the Ingersoll-Rand Company. The locomotive actually represents a further development of two locomotives built by the General Electric Company in 1917 and 1918, which were doing regular yard switching work at the Erie works of the company. One of these was the Jay Street oil electric locomotive. Several other locomotives, practically duplicates of the last-mentioned one, have been built since 1923 by the same two companies jointly with the American Locomotive Company. In these the prime mover is a six-cylinder, four-cycle, single-acting oil engine with airless injection built by the Ingersoll-Rand Company. The engine develops 300 b.hp. at 600 r.p.m. and weighs only 19,355 lb., or 64.5 per b.hp. One oil-fuel injection pump serves all six cylinders through a properly timed six-feed distributor of a special design. Each cylinder has a separate combustion chamber with two opposed spray nozzles, the combustion chamber being connected with the cylinder by a narrow neck for creating turbulence and proper combustion (Price-Rathburn system). The generator is a 200-kw., 600-volt, compound-wound, 6-pole, direct-current dynamo directly fastened to the oil-engine brake shaft. There are four geared motors, one for each axle, mounted on the trucks. The motors are of the series-wound, totally-enclosed, commutating-pole, split-frame type, rated 95 hp. at 600 volts. They are arranged in two pairs, which are permanently connected in multiple, and these pairs can be coupled in series usually for speeds below 5 miles per hour, or in parallel for speeds above 5 miles per hour. The output of the generator is automatically adjusted to suit the varying train resistance. This is done by inserting a commutating field and a differential series field in the current line, thus modifying the excitation field of the generator so as to give the proper proportion of amperage for the tractive effort and of voltage for the speed. No rheostats are used in the power circuit for speed control. The position of the control handle determines only whether the motors are connected in series or in parallel or in reverse, and another handle, which is the only operating handle, affects the throttle controlling the power generated by the oil engine. Further speed control goes on automatically with the proper division of power into tractive effort and speed. This system known as the automatic or Lemp control, has been used very extensively by the General Electric Company for gas-electric motor buses, motor rail cars and locomotives.

The first 300-hp. 60-ton, oil-electric locomotive has been doing switching work on various roads in this country.

A great stride in the development of oil-electric traction was made when the 1000 hp. locomotive for Russia was built in 1924 in Germany. This locomotive is of the 2-10-2 type. The prime mover has six sylinders 17¾ in. bore by 16½ in. stroke. It is a four cycle air blast injection engine of the submarine type, development its full power 1000 hp. at 450 r.p.m. The direct current electric generator is connected directly with the Diesel engine. The exciter is driven from the generator shaft by means of wheels with a ratio of 1:2. The field of this exciter is in turn energized by another small exciter driven by a belt from the shaft of the first exciter. The field of the latter exciter is fed by a current from a storage battery through controllers placed in the engineer's cabs at both ends of the locomotive. Thus a very gradual change in voltage is obtained which as a consequence gives a very flexible control of speed and tractive effort with small resistance losses in the electric transmission. Five direct-current electric motor of the tramway type are geared to the driving axles, one motor to each axle.

The locomotive weighs 133 tons, of which 100 tons is weight on drivers and 33 tons that on front and rear supporting axles. The weight of the electric transmission and control amounts to 51.2 tons. The locomotive develops from 840 to 890 rail hp. at the maximum output 1200 hp. of the oil engine.

At the Fair in Milan, Italy, in the summer of 1924 a 400 hp. Diesel electric locomotive of the 0-4-4-0 type was exhibited. It was built by Franco Tosi Societa Anonima, Diesel engine manufacturers in Legnano, Italy. The prime mover is an eight-cylinder four cycle, single acting oil engine of the well known Tosi design with air blast oil injection developing 400 b.hp. at 300 r.p.m. The engine is geared to two direct current generators at 170 kw. each, delivering the current to four 95 hp. motors geared to four driving axles. The locomotive weighs 66 tons and is supposed to pull a train of 99 short tons at a speed of 37 to 43 m.p.h.

A similar 0-4-4-0 Diesel-electric narrow gage locomotive was built by the Fiat Company for the Calabro-Lucane Railroad in Southern Italy. It is driven by a six-cylinder, two-cycle engine developing 440 b.hp. at 500 r.p.m. A 250-kw. separately excited generator is directly coupled to the Diesel engine and gives, at 500 r.p.m. a variable voltage of from 300 to 500 volts. Four motors of the railway type, rated at 72 hp. continuous operation, are geared to driving axles. The speed control is obtained by varying the excitation of the dynamo.

Recently the Baldwin Locomotive Works completed a 1000-hp. oil electric locomotive. It is of the 2-4-4-2 type and is driven by a 12-cylinder Knudsen oil engine through a Westinghouse electric transmission. This locomotive was described in considerable detail in the November, 1925, issue of RAILWAY AND LOCOMOTIVE ENGINEERING.

One of the latest combinations of an oil engine with electric transmission has been employed in rail cars built for the Canadian National Railways. Seven 60ft. single cars and two 102-ft. articulated cars have already been placed in service. The engines are modified four-cycle solid-injection Diesel engines of the airplane type built by William Beardmore & Co., Ltd., London, England, and have four 8¼ by 12-in. cylinders for the small unit

and eight cylinders of the same size for the large unit. The two engines develop 185 b.hp. at 700 r.p.m. and 340 b.hp. at 650 r.p.m., and weighs 15 and 16 lb. per b.hp., respectively.

As regards electric equipment, the small unit has a 105-kw., 600-volt, direct-current, British Thomson-Houston differentially compound-wound generator with a 6kw. 60-volt separate exciter, and two 150 ampere 600-volt General Electric motors which drive the front truck axles through helical gears. The car speed is controlled by the oil-engine throttle and the Lemp automatic control system. The operating handle controls the throttle and another handle connects the motors to the generator circuit in series or parallel, or in reverse. The large unit has a Westinghouse 200-kw., 600-volt direct-current differentially compound-wound generator with excitation from a 300-volt battery, and four 145-ampere 600-volt Westinghouse motors connected permanently in parallel and driving the front and rear truck axles through helical gears. The car speed is controlled by the modified Ward Leonard system—with constant engine speed by governor and by resistances in the main generator field and by eight electro-pneumatic switches. The starting of the oil engines on either car is affected by driving the generator as a motor from a battery. The weights of the cars are 101,000 and 188,000 lb. respectively.

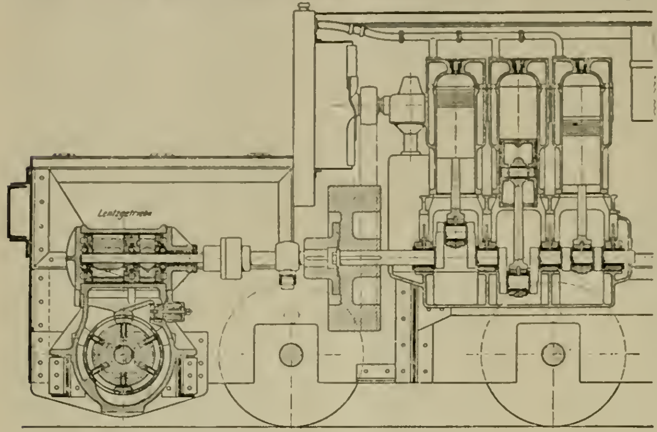


Fig. 1—Diesel-Lentz Locomotive

A further development of the 60-ton 300-hp. oil-electric locomotive described above is a 100-ton locomotive of twice the power. One engine of this type has been recently delivered to the Long Island Railroad. The locomotive differs from the 300-hp. locomotive in that two 300-hp. Ingersoll-Rand oil engines instead of one are used, together with two 200-kw. 600-volt direct-current generators, each generator being directly connected to the corresponding oil engine. The motors are four in number as in the 300-hp. locomotive, but differ of course in size. They are rated 200 hp. at 600 volts, and are of the series-wound, commutating-pole type manufactured by the General Electric Company. The locomotive was delivered in December, 1925, to the Long Island Railroad for switching work at Morris Park.

2—Hydraulic Transmission

When the Diesel locomotive built in Germany in 1913 with the engine directly connected to the driving wheels failed to perform the required work for reasons which will be given later, the German Railway Administration was looking for some sort of a flexible transmission of power. The author does not know why electric transmission was not resorted to, but it happened at the time that Hugo Lentz had just brought out a design of a hydraulic transmission and the German Railway Administration decided to try it out. Accordingly a small 30-hp. Diesel locomotive with Lentz transmission was built, the tests were considered encouraging, and several more locomotives were ordered for experimental purposes.

The 30-hp. Diesel-Lentz locomotive (Fig. 1) is a small 0-4-0 switching engine. It was built in 1921 by the firm of A. Gmeinder & Co., Mosbach, Germany, which was re-organized later into the Badische Motor-Lokomotiv-Werke A.G. The locomotive consists of a three-cylinder, four-cycle Diesel engine built by Benz, with a Lentz hydraulic gear connected by means of coupling rods with two driving axles, and with a water cooler in front of the locomotive similar to coolers of the automobile type. The Benz engine is a three-cylinder Diesel engine simplified for application to locomotives and adapted to the use of heavy oils. It runs at a maximum speed of 500 r.p.m. and is provided with a flywheel and a governor. The engine shaft is located parallel to the longitudinal axis of the locomotive.

The Lentz hydraulic transmission, or gear, as it is usually called for the reason that it does not change the speed of the propelled shaft gradually but stepwise, consists of two parts, a rotary pump attached to the prime mover and a rotary hydraulic motor connected to the driving (jack) shaft (Fig. 2). The pump is in line with the oil engine and has two or more revolving pistons (or one may call them disks) of different width. The motor has only one piston and its axis is parallel to that of the driving axles and at 90 deg. to the axis of the pump. Each piston has several very light sliding vanes which fit nicely in grooves in the piston. The disks revolve between nicely fitted covers made of hard bronze. The vanes are pro-

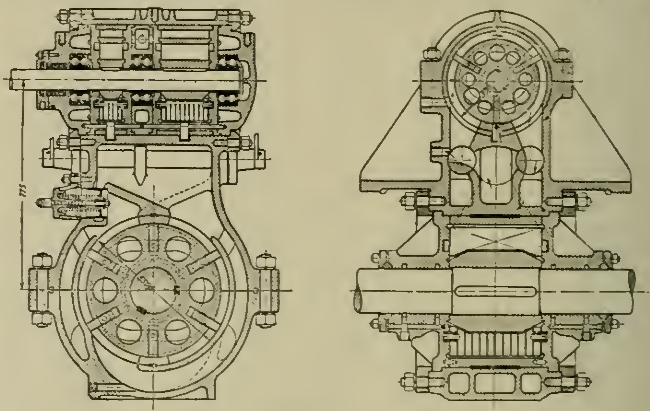


Fig. 2—Lentz Hydraulic Transmission

vided on both sides with pins and rollers which fit into grooves cut out in the covers. The grooves are made partly of a concentric, partly of an eccentric, shape. The motor has a similar arangement but it usually differs in that it is made double-acting with double the number of vanes. The fluid (lubricating oil) works in a circle; it is pumped into the motor and having performed its work it is led back into the suction passage of the pump. The speed of the motor is in proportion to the ratio of the volumes swept by the pistons of the pump and of the motor. If the pump is provided with two pistons with a ratio of volumes of 1 to 2, then the speeds of the motor can be obtained: (1) with the small piston only, the larger running idly; (2) with the large piston only, the smaller running idly; and (3) with both pistons running simultaneously. The ratio of the speeds would be 1:2:3. For the idle running of one piston or another the cocks should be placed in such a way as to establish communication between the pressure and the suction chambers of the pump: then the fluid passes through the pump only, with practically no pressure at all. By placing the cocks so as to connect the pump with the motor, the fluid is forced into the motor with a pressure corresponding to the load on the driving shaft and returns to the suction chamber of the pump with practically no pressure. By reversing the position of the cocks between the pump and the motor, the rotation of the motor can be reversed. There are two cocks for each piston, and their relative position can be changed independently, thus making as many speeds available for backward running as there are forward speeds. If all the cocks are placed in the idle position, the driving shaft remains immovable. In order that variation of speed may take place smoothly, without shock, the gear is provided with a throttle valve which is opened every time the speed is changed; in this way a sudden rise of pressure in the gear is prevented and a more uniform variation of speed obtained. This valve also serves as a safety valve if the spring is set at a certain pressure. It also permits the use of the motor as an emergency brake by reversing the position of the cocks while the driving shaft continues to rotate in the same direction, thus forcing oil into the pump in a direction opposite to the rotation of the oil engine. The safety valve prevents breakages which otherwise would take place.

An oil tank is provided on top of the hydraulic gear and is connected by means of pipes with the inlet chamber of the pump and the outlet chamber of the hydraulic motor. This arrangement makes it possible to keep the gear filled with oil and prevents the foaming that would take place if air were permitted to enter and mix with the oil.

The locomotive weighs 12.12 tons and has a tractive effort of 5280 lb. The engine can be run at 3 different speeds—2.5, 5.0, and 7.5 m.p.h. and pulls on a level a train of 132 tons.

The results obtained with the 30-hp. Diesel-Lentz locomotive appeared to be so satisfactory that many builders in Germany and Austria began the construction of larger locomotives.

At the same time the German firm that built the first 30 hp. Lentz locomotive, jointly with the Maschinenbau Gesellschaft Karlsruhe, of Karlsruhe, Germany, developed a 160-hp. Diesel-Lentz locomotive and built three 0-4-0 locomotives of this size for the German State Railways. These were provided with a cooler for cooling the oil used in the gear, which was found necessary for Lentz gears of higher power. These locomotives have been in service on the German State Railways since early 1925.

At the time when the Lentz transmission was being developed in Germany, a 0-4-0 150-hp. switching locomotive was built in Canada with the Universal hydraulic transmission developed by the Universal Engineering Corporation in Montreal. This transmission is also known as the Williams-Janney or Waterbury gear. The two parts of the transmission were separated, the primary part—the pump—being attached to the prime mover, and the secondary—the motors—acting directly on the driving wheels. The pump and the motors were connected by pressure and suction pipes, the whole arrangement resembling very much an oil-electric locomotive with motors directly attached to driving axles. The locomotive exerted a tractive effort of 12,000 lb. at starting and 3000 lb. at 12.5 m.p.h. The gear permits an infinite change of speed from zero to maximum.

The Universal Engineering Corporation has applied the variable-speed gear to a passenger rail car which has been in service on the N. Y., N. H. & H. Railroad for the last two years.

A similar locomotive with a 75-hp. Diesel engine and Williams-Janney transmission was built some years ago by Vickers in England, and has been since in continuous service doing switching work in the Vickers plant at Barrow-in-Furness.

At the Exhibition in Seddin, Germany, in 1924, the Berliner Maschinenbau A.G. (vormals L. Schwartzkopff), of Berlin, exhibited a 0-4-0 Diesel locomotive with an oil transmission of a new design known as the Huwiler gear (Fig. 3). This latter consists of a hydraulic pump and motor, both of the vane type, similar to the Lentz gear but differing from it in that the pump delivers an infinitely variable quantity of oil to the motor, thus permitting an infinite variation in speed. This is obtained in the following way: Bushing 4 with extensions fits into the pump piston 1 and into the space between vanes 2, and can be displaced longitudinally between the vanes so as to release longer or shorter vane working surfaces. The bushing with extensions rotates together with the pump piston and vanes, but the displacement of the former is controlled by an outside fixed wheel. The pump and motor are built in two separate units connected with pipes, but they can be built in one unit with axes at 90 deg. similar to the Lentz arrangement.

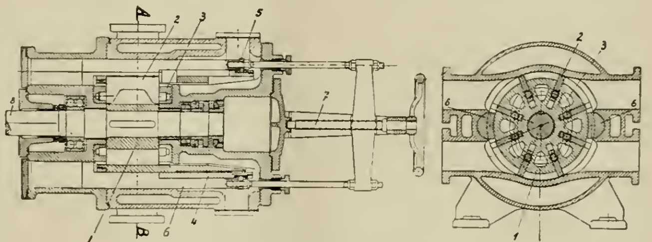


Fig. 3—The Huwiler Gear

The prime mover is a six-cylinder air-blast-injection Diesel engine developing 200 hp. at 440 r.p.m. The cooler, which is provided with a fan, is located on the roof of the car.

In addition to the above-mentioned types, there are several other hydraulic transmissions, such as the Hele-Shaw gear, the Naeder drive, and the Lauff-Thoma transmission, which have been tried with some success on small gasoline or kerosene locomotives, rail cars, and automobiles. Primarily designed for slow and occasional work, such as ship steering, rotation of gun turrets on ships, and operating machine tools, they were later proposed for

light traction work but with much less success. The Hele-Shaw gear seems to have been favored more than the others, and in 1913 it was applied to a rail car built in England for Canada, and later to several small switching locomotives built in France.

The difficulty with hydraulic transmission seems to lie in the low efficiency resulting from the heating of the oil, which, once started has a tendency to increase its temperature very rapidly. It seems that the presence of air in the oil effects very materially this rise in temperature, and that some transmission are more likely to absorb air when running than others. Lentz, for instance, claims that he has entirely overcome this difficulty. This may be due to the low pressure which he employs—about 50 to 150 lb. per sq. in. at full speed and 400 to 500 lb. per sq. in. at starting while other use pressures of from 400 to 600 and 1200 to 1500 lb. per sq. in., respectively.

3—Pneumatic Transmission

The idea of pneumatic (air) transmission is probably one of the first types which occurred to those interested in Diesel-locomotive design. As far back as 1909, V. A. Stuckenberg, general manager of the Tashkent Railroad in Russia, suggested rebuilding steam locomotives in the following way: to replace the tender by a unit carrying a Diesel engine and compressor, to use the boiler as a compressed-air storage tank, and to let the air work in the existing locomotive cylinders in the same way as steam. The project was not considered at that time practicable, and the idea was abandoned.

About the same time James Dunlop, of Glasgow, Scotland, came out with a similar proposition. A design of a 1000-hp. locomotive was worked out and published.

The Maschinenfabrik Esslingen, the German locomotive firm that built the 1000-hp. Diesel-electric locomotive for Russia is now building a 1200-hp. locomotive with air transmission (Fig. 4). With this system the compressed air is heated on its way to the locomotive cylinders by the exhaust gases of the oil engine. Dr. Geiger, one of the leading engineers of the Maschinenfabrik Augsburg Nurnberg (M. A. N.) in Augsburg, who in 1918 suggested this improvement over the Stuckenberg-Dunlop scheme, estimates that 58.5 per cent of heat contained in the oil engine exhaust gases which otherwise would be lost, can be recovered in the heated compressed air. The overall thermal efficiency be thus computes at 26.9 per cent. The design consists of a six-cylinder submarine type M. A. M. engine which drives a compressor. Air compressed to about 110 to 125 lb. per sq. in. and thus already heated to about 500 deg. Fahr. is further heated by the exhaust gases to approximately 700 deg. Fahr. The two cylinders which are placed in front of the locomotive, the valve, valve motion rods, and other running parts are of the well known locomotive type, as are also the frames, boxes, springs, trucks, wheels, etc. The engine bedplate fits into the locomotive frame, which is of the bar type; the wheel arrangement is 4-6-4. Special tests preceded the working out of the design. A small compressed-air model had run in 1919, and later, in 1923, a one-cylinder full-size installation had been tested. The preliminary test results served as a basis for the present design.

4—Steam Transmission

Instead of air, steam working in a closed circuit was suggested several years ago by Cristiani, of Milan, Italy. In his design, steam from a high-pressure container is superheated by the exhaust gases of a Diesel engine and expanded in ordinary steam cylinders; it is then expelled at 25 to 30 lb. per sq. in. into a low-pressure receiver which is cooled by atmospheric air driven by a fan. A steam compressor then draws the cooled steam from the receiver, compresses it to approximately 180 lb. per sq. in. and rejects it to the high-pressure container, after which it is again superheated, expanded, etc. The steam compressor is directly driven by a Diesel engine, and the total out put of the latter is transformed into compressed-steam energy which is utilized in the locomotive's steam cylinders.

The steam needed for the process is first obtained from a small boiler, which later serves to replenish the amount lost through leakage, condensation, etc.

Cristiani, however, does not anticipate any condensation,

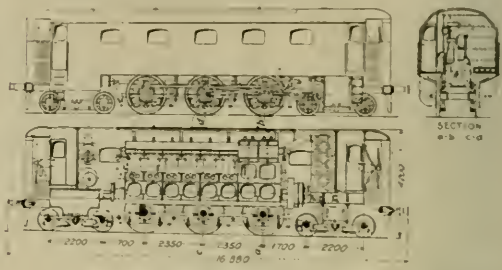


Fig 4—1200 Horsepower Diesel-Electric Locomotive with Air Transmission

as he thinks that the steam will always be superheated. He estimates the efficiency of the transmission to be 70 per cent, giving a total overall efficiency of 23 per cent for the Diesel locomotive. He thinks that the design of the steam-transmission parts (compressor, superheater, etc.) is simpler and the construction of these parts cheaper than is the case with any other form of transmission.

In 1923 Cristiani started the construction of a 900-hp. locomotive for the Northern Railway of Milan. The locomotive is of the 0-8-0 type and is driven by two six-cylinder 450-hp. two-cycle Diesel engines at 500 r.p.m. There are two steam compressors driven separately by each of the two Diesel engines.

5—Aero-Steam Transmission

The expansion of air in working cylinders is usually accompanied by a rapid drop in temperature. This was the stumbling block in the way of the first air-transmission projects. An Italian engineer, Fausto Zarlatti, thought that he might be able to overcome this difficulty by mixing the air with steam and thus keeping the air warm during expansion due to the smaller fluctuation in temperature of the expanding steam. He suggested, therefore, an aero-steam transmission, and even went so far as to rebuild a small six-wheel locomotive which he received from the Northern Railway of Rome. A six-cylinder gasoline engine of approximately 70 hp. drove an Ingersoll-Rand air compressor. The engine and compressor were mounted on the tender, and compressed air was stored in the old locomotive boiler partly filled with water. The air preheated by compression before entering the working cylinders, must have passed through the column of water in the boiler and thus been saturated with vapor. In addition, use was made of the heat contained in the exhaust gases of the gasoline engine; these gases passed through the boiler and generated a certain amount of steam. The mixture of air and steam was admitted to the cylinders by means of the existing throttle and reverse lever. The locomotive with its tender thus reconstructed weighed 42 tons.

James Dunlop, of Glasgow, who back in 1909 proposed to employ air transmission, came out lately with a new design of a main-line 1100-hp. locomotive with an aero-

steam transmission. The prime mover is a six-cylinder, two-cycle, airless-injection oil engine of specal design with air-compressing cylinders placed on the top of working cylinders of an annular shape. Steam of 200 lb. pressure, generated in a boiler heated by the exhaust gases of the oil-engine cylinders, is superheated by the compressed air, with which it mixes; this is supposed to result from the fact that compressed air at 200 lb. pressure is over 200 deg. Fahr. higher in temperature than steam at 200 lb. pressure. The water space of the boiler is connected with the water-cooling jackets of the oil engine, similar to the arrangement used in the Still engine.

Exhaust Gas Transmission

With compressed air transmission there is always danger of lubricating-oil ignition, and special precautions must be taken to avoid this. In order to eliminate the slightest possibility of an oil explosion, it was suggested that an inert gas be used instead of air. In the case of an oil-engine locomotive the most convenient gas to use would, of course, be the exhaust gas from the engine itself.

Several years ago the Waggon und Maschinenbau A. G. Gorlitz, of Gorlitz, Germany, patented a system of transmission for oil-electric locomotives by which the oil-engine exhaust gases are compressed and expanded in ordinary locomotive cylinders. The same firm, jointly with Berliner Maschinenbau A. G., vormals L. Schwartzkopff, of Berlin, Germany, actually built a 0-4-0 locomotive (Fig. 7) embodying the principle which was shown in 1924 at the Exhibition in Seddin. The prime mover of the locomotive which drives the exhaust-gas compressor in a 220 hp. Diesel engine running at 500 r.p.m. The exhaust gases of the engine are first cooled then compressed to about 115 to 140 per sq. inch, and cooled at the same time, and only afterward, when the cooling if finished are the compressed gases heated to approximately 660 deg. Fahr. by the exhaust gases on their way to the cooler. The object of cooling the gases before and during the compression is to keep the size of the compressor and the power absorbed by compression as low as possible.

Illinois Central Begins Electric Operation

Electric train service was formally inaugurated in Chicago on August 7, with the official opening by the Illinois Central Railroad of the electrified section of its suburban tracks. This is the diamond jubilee year of the Illinois Central, which was granted a charter by the state in 1851, and this is the first time that electric trains have operated on the steam roads of Chicago. The railroad carries more than one-third of all the suburban passenger traffic in Chicago.

The Chicago terminal improvements include, among other extensive changes, the electrification of the suburban freight and through passenger operations. The initial electric operation handles the suburban traffic from the central station at Randolph to Matteson 28 miles south, to South Chicago over a 4.8 mile branch and to Blue Island over another branch 4 miles in length. At the present time about 87,000 suburban passengers are handled every week day on 418 trains. An increase in this business is expected in the near future, bringing the total up to more than 100,000 passengers daily.

In addition to the elimination of smoke, noise and dirt, marked improvements are being made in the running time of trains, reducing the schedules by from 15 to 30 percent. Special trains serving golf enthusiasts have been added to reach seven different golf clubs at suitable times of the day to accommodate patrons both leaving the city and returning.

During the morning rush, 57 local, express and special trains are being operated between the hours of 7:30 and 9:30; thus averaging a train every two minutes. During the evening rush, from 4:30 to 6:15, similar service is provided, with a total of 48 trains.

Rolling Stock

All of the suburban passenger business will be handled with trains made up of equal numbers of 1,500 volt direct-current motor cars and similar trailing units without motors. The initial equipment includes 130 steel motor cars and 85 new trailers which will be used with 45 steel cars now in use, making a total of 130 two-car units. The motor car and trailer bodies are similar except that the under frame of the motor car is designed with additional strength for supporting the control apparatus and the roof is designed to permit the installation of pantograph collectors. Following are the general dimensions of these cars:

Gauge	4 ft. 8½ in.
Length over buffers	72 ft. 7½ in.
Length between truck centers	47 ft. 9 in.
Width overall at eaves	9 ft. 11½ in.
Number of cross seats, each side	17
Capacity of cross seats	68
Capacity of longitudinal seats	16
Total seating capacity of car	84

Each motor truck carries two 250 horsepower motors and is of the swing-bolster equalized type, having a wheel base of 8 ft. 3 in. The wheels are 38 in. in diameter. Trucks for the trail cars have a wheel base of 6 ft. 3 in. and 33 in. wheels. The following are the estimated weights of motor, trail car and complete unit:

Weight of motor car, without motors, control, or passengers	49.26 tons
Weight of trailer car, without control or passengers	44.32 tons
Weight of unit, total	93.58 tons

The length of run for these trains between stops varies from 0.34 miles for the local service to 14 miles in special service. Each of the four motors has an hourly rating of 250 horsepower and a continuous current rating of 190 horsepower. The gear ratio is 60/21 and provides for a straight line acceleration of 1.5 miles per hour per second, and a balancing speed of 57 miles per hour based on the assumption of 1,350 volts at the trolley.

Two pantographs are installed on each motor car, designed for a normal operating height of 22 feet with a range from 16 to 24 feet above the rail head. The pantographs are spring raised and air lowered and all of the collectors in the train may be controlled from any cab.

The control on all of the cars is of the electro-pneumatically operated type, designated as type PC-103 and built by the General Electric Company. Two independent electric-pneumatic line switches connected in series are arranged to open all circuits under power. The control devices are operated from a 32-volt supply. Acceleration is automatically controlled by means of current limit relays

but provision is made for positive manual acceleration, if desired. There are seven full-field series steps, five full-field parallel and one normal-field parallel step. The master controller has four running points, switching which is series connection with all resistance in circuit, series, by pass for manual notching and parallel for the full running position. The master controller is interlocked with the brake apparatus to prevent the application of power unless the brakes are operated from the same cab.

Air Brake Equipment

Electro-pneumatic brakes are used with a motorman's valve, which is a combination electric and air so constructed that, in case of failure of the electric control, brakes may be applied in the usual manner without any attention on the part of the operator.

This equipment provides for service braking at a rate of 1.75 mile per hour per second and emergency braking up to 3 miles per hour per second. Compressed air is supplied by a 35 cu. ft., 1,500 volt direct current. General Electric air compressor, and governors are used which operate all compressor switches simultaneously.

The control current is supplied by a 3½ kw., 1,500-volt motor-generator set which is installed on each motor car. This unit consists of a double commutator motor and a 37-volt generator mounted in the same frame. A 24-cell, 300-ampere-hour Edison type battery is connected to float on the line with a charging regulator of the carbon pile type. The use of a kilowatt-hour meter installed in the motor circuits of each car permits inspection of the cars on a kilowatt-hour basis if desired.

Power for the entire Illinois Central electrification is supplied by the Commonwealth Edison Company, with whom the railroad has entered into a 10-year contract. The Edison Company owns and operates seven 1,500-volt direct current substations located as indicated in the table herewith. These stations are located at points specified by the railroad company, but are maintained and operated by the Edison Company. However, the power director of the railroad may give orders relating to the operation of feeders directly to substation attendants.

The substation machinery includes 33,000 kilowatts in synchronous converters and 9,000 kilowatts in mercury arc rectifiers. All of the converters are 3,000-kilowatt sets, each consisting of two 1,500-kilowatt converters connected in series and receiving power from a single centrally located transformer. The converters are of the shunt wound type with an overload rating of 300 percent for one minute and with specially designed regulating equipment for fulfilling the voltage regulations specified in the contract, namely, from 1,550 to 1,400 volts under normal and regular load conditions. The mercury rectifier installation constitutes the first extensive use of the device in the United States, although it has been used for some time in Europe.

There will be no positive feeders from these substations in addition to the catenary messengers and the double contact wires, the contact system over each main line track being independent electrically. The synchronous converters are all of General Electric manufacture, and complete protection is given by General Electric high speed circuit breakers. All of the mercury arc rectifiers supplied by the General Electric Company are the 1,500-kilowatt size, each unit consisting of two 750 kilowatt tanks each arranged with six anodes for six-phase operation.

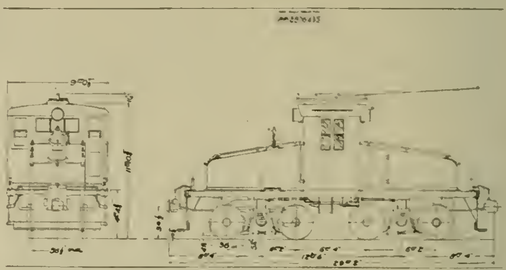
The catenary system, as above mentioned, provides all of the required conducting cross-section for supplying current to the motor cars without additional feeders. This equipment was designed by the railroad company's engineers and covers at present from two to six parallel tracks on the main line and single and double track on the branches. There are a total of 110 track-miles, covering 38 miles of route.

The catenary over all main tracks consists of a positive main messenger of high tensile strength, two bronze or copper grooved contact wires and a hard drawn auxiliary messenger. Unusual flexibility is obtained in the contact line by a highly flexible 19-strand auxiliary messenger. This is supported by the main messenger spaced at 20-foot intervals north of 67th Street, and 15-foot intervals south of 67th Street. Clips for the contact wires are spaced at half this interval and each contact wire is supported from alternate clips. The bronze contact wire, therefore, used in the heavy traffic section is supported at 20-foot intervals and the copper contact wires in the outside sections at 15-foot intervals.

The bonding is the same throughout consisting of a single 4/0 bond applied to every joint of each rail. The normal spacing of the catenary structures is 300 feet, and provision is made for extending these structures over additional tracks when the remaining freight tracks are electrified.

New Type of Electric Switching Locomotive

A new type of switching locomotive, known as the frameless truck type, has recently been supplied to the Delaware, Lackawanna and Western Railroad by the General Electric Company. The most important feature of this design is the truck, which is a departure from the usual construction of swivel truck locomotives. In place of the customary two axle bearings of the motor and the two truck journal bearings, the motor itself is modified in its external construction and provided with a single sub-



Electric Switching Locomotive Delaware, Lackawanna & Western Railroad

stantial bearing in place of the usual auxiliary bearings. The gears occupy their usual location, but no external journals are used. On this account, the locomotive has the appearance of what is commonly called the inside-hung bearing type of truck design. The locomotive is of the usual steeple cab type, with the platform made up of a single semi-steel casting.

Each motor frame is cast with two pairs of lugs directly over the axle bearing to receive the ends of the equalizers. A substantial pin passes through the end of an equalizer, and the lugs are so spaced as to serve as guides for the equalizers.

Two equalizers forged from steel bars perform the usual functions of truck equalizers in supporting the transom and, in addition, tie the trucks together and hold the parts in alignment.

The steel bolster is cast with the truck portion of the center plate with recesses and lugs for the motor noses

and safety lugs and with slotted extensions for the brake hangers and levers.

The transom, supporting the weight of the superstructure, the brake rigging and about half the weight of each motor, is in turn carried on coil springs which rest in spring hangers suspended from the equalizers.

Vertical slots in the transom at opposite sides of the center plate serve as guides for the two equalizers.

The electrical equipment consists of four GE-207, 110-horsepower motors, similar in all respects to the usual railway type motor except in the external form of the frame. Type M control is used, including the master controller and the necessary auxiliary contactors and rheostats. Compressed air is furnished by a 600-volt motor-driven air compressor having a rated piston displacement of 50 cubic feet of air per minute.

The specifications of the new type locomotive:

Overall length	29 ft. 2 in.
Overall width	9 ft. 0⅞ in.
Height over cab	11 ft. 9¾ in.
Height over trolley lock down	16 ft. 8¼ in.
Maximum height, trolley up	25 ft. 6 in.
Total wheel base	18 ft. 8 in.
Rigid wheel base	6 ft. 2 in.
Diameter of driving wheels	36 in.
Minimum radius of track curvature	45 ft.
Total weight, all of drivers	100,000 lbs.
Weight per driving axle	25,000 lbs.
Operating voltage	600 v., d-c.
Motors	Four GE-207G.

Canal Transportation Cost Over Twice That of Rail

The total cost of freight transportation on the New York State Barge Canal is more than twice that by rail in the same territory, according to a study just completed by the Bureau of Railway Economics.

"The State of New York," according to the study, "has built and owns the New York State Barge Canal, having issued special canal bonds to meet the cost of construction. The State also maintains the canal, which is open to the public as a transportation agency free of toll. In other words, the people of the State of New York have taxed themselves and are continuing to tax themselves to build and maintain a free waterway.

"The only cost incurred by a shipper of freight on the canal is the charge he pays to the operator of the barge which carries his freight, together with storage and terminal charges and insurance; and the barge operator's charge is low because he is under no expense for the use or maintenance of the watehway, and his only capital investment is in his boat. Because it is government property, no taxes are assessed on the canal or its terminals and warehouses, which fact further reduces the cost of transportation by canal.

"In figuring the total cost of transportation via the canal, however, not only the boat operator's charges must be included, but also the cost of carrying the capital invested by the State in the canal, as well as the annual cost of maintenance, repair and depreciation."

To transport a ton of freight one mile by the canal cost 2.533 cents in 1925, according to the Bureau of Railway Economics, while the total cost by rail was 1.108 cents. Since 1922, the comparative costs for carrying a ton of freight one mile have been as follows:

Year	*By canal*	*By rail*
1922	3.648 cents	1.172 cents
1923	3.481 cents	1.104 cents
1924	3.260 cents	1.122 cents
1925	2.533 cents	1.108 cents

"Despite the considerable reduction in canal costs in 1925, due in part to reduced maintenance expenditures and in part to the increase in traffic, the total cost of transportation by the Barge Canal in 1925 was more than twice as much as by rail in the same territory," the Bureau continues. "Were it possible to foresee a considerable further increase in traffic and also a considerable further reduction in maintenance costs, the canal cost per ton-mile would correspondingly decline. But it is the considered judgment of New York State officials most directly responsible for canal affairs that no great further increase in traffic can be expected under present conditions on the canal, while on the other hand these officials all expect a marked increase in maintenance costs, to say nothing of necessary expenditures to meet depreciation and obsolence."

Notes on Domestic Railroads

Locomotives

The Abilene Southern Railway has ordered one Mikado type locomotive from the American Locomotive Company.

The Chesapeake & Ohio Railway has awarded contracts for the repair of ten Mallet locomotives to the American Locomotive Company, 10 to the Newport News Shipbuilding & Drydock Company and 5 to the Erie Railroad at Hornell, New York.

The Pennsylvania Railroad will build 7 electric locomotives at Altoona, Pa., shops. The American Brown Boveri Corporation will furnish the electrical equipment.

The Atchison Topeka & Santa Fe Railway has ordered 40, locomotive tenders from the Baldwin Locomotive Works.

The Buffalo Creek & Ganley Railroad has ordered one consolidation type locomotive from the Baldwin Locomotive Works.

The Richmond Fredericksburg & Potomac Railroad contemplates buying 6 Pacific type locomotives.

The Alaska Railroad is reported to be in the market for 2 Mikado type locomotives.

The Norfolk & Western Railway is inquiring for 10, 2-8-8-2 type Mallet Locomotives.

The New York Central Railroad has ordered a 100-ton oil electric locomotive from the Ingersoll-Rand, American Locomotive Company and General Electric Company.

The St. Paul Bridge & Terminal Railway is in the market for one eight-wheel switching type locomotive.

The Royal State Railway of Siam has ordered 8, three-cylinder Pacific type locomotives from the Baldwin Locomotive Works.

The Texas Mexican Railway has ordered one 4-6-0 type locomotive from the Baldwin Locomotive Works.

The Tennessee Coal Iron & Railroad Company is inquiring for one switcher.

The Shanghair Nanking Railway is said to be in the market for 13 locomotive boilers.

The Delaware & Hudson Company contemplates having an experimental high pressure consolidation type locomotive built by the American Locomotive Company.

Passenger Cars

The Richmond Fredericksburg & Potomac Railroad has ordered one dining car from the Pullman Company.

The Chicago Milwaukee & St. Paul Railway is preparing specification for 5, 70 foot gas electric cars.

The Canadian National Railway has ordered 2 passenger car underframes for use in its Montreal shops from the Eastern Car Company.

The Reading Company has ordered 4 cafe cars from the Pullman Company.

The Chicago, Milwaukee & St. Paul Railway is inquiring for 5, 70 foot gas-electric cars, including 2 passenger-baggage, 2 mail-baggage and one baggage car.

The Chicago Rock Island & Pacific Railway has purchased 2, 550 hp. gas electric power units each consisting of 2, 275 hp. distillate burning engines with electrical equipment to install in 40 foot steel cars for branch service from the Electro Motive Company; also 5, 275 hp. single units of the same type for installation in 70 foot car bodies from the same company.

The City of Philadelphia is inquiring for 150 subway cars complete and 10 extra car trucks.

The National Railways of Mexico has ordered 10 mail express

and 5 baggage express cars from the Pullman Car & Manufacturing Company.

The Timiskaming & Northern Ontario Railway has ordered 3 all steel first class cars and 3 all steel second class cars from the National Steel Car Corporation.

The Canadian Pacific Railway has ordered 10 steel passenger cars from the Canadian Car & Foundry Company, the cars to be completed in the Angus Shops at Montreal.

The Reading Company has ordered 15 all steel passenger coaches from the Standard Steel Car Company.

Freight Cars

The Louisville & Nashville Railroad is inquiring for 2, 75 ton flat cars.

The General Sugar Company has ordered 100 cane cars of 30-ton capacity from the Magor Car Company.

The Dierks Lumber Company has ordered 8 flat cars from the Mt. Vernon Car & Manufacturing Company.

The Norfolk & Western Railway will build 250, 57½ ton flat cars at its shops at Roanoke.

The Canadian Pacific Railway has received 71, 75-ton coal cars from the Canadian Car & Foundry Company.

The Chesapeake & Ohio Railway has contracted for repairs to 500, 70-ton hopper cars with the Richmond Car Company.

The Pennsylvania Oil Products Refining Company has ordered 2 double compartment 6,000 gallon tank cars from the Standard Tank Car Company.

The New Orleans Public Belt Railroad is inquiring for 50, 40-ton single sheathed box cars.

The Asiatic Petroleum Company is inquiring for 4 oil-tank cars for export.

The Pere Marquette Railway is inquiring for 25, 30-ton all steel hopper cars with 40-ton trucks.

The Chicago Great Western Railway is inquiring for 300 box and 200 automobile cars.

The Cuban American Sugar Company has ordered 100 cane cars from the Gregg Car Company.

The Georgia & Florida Railway has ordered 20, 50-ton gondola cars from the American Car & Foundry Company.

The Hegler Zinc Company is inquiring for 10, 70-ton tank cars.

The Public Service Company of Northern Illinois has ordered 3 50-ton all steel gondola cars from the American Car & Foundry Company.

The Canadian Pacific Railway has received 7 steel baggage cars from the National Steel Car Corporation.

The Cities Service Tank Line has ordered 5, tank cars from the American Car & Foundry Company.

The Norfolk & Western Railway is inquiring for 250 flat cars.

The Chesapeake & Ohio Railway is asking for bids on 500 hopper bottom gondola cars.

The East Jersey Railroad & Terminal Company has ordered 10 tank cars from the American Car & Foundry Company.

The Hainesport Mining Transportation Company has ordered 10, 50-ton hopper cars from the American Car & Foundry Company.

Building and Structures

The Missouri Pacific Railroad is planning to build a repair shop at Hot Springs, Ark., including 2 heating plants, 2 train sheds, a 50,000 gallon water tank and a large cinder conveyor.

The Chicago Great Western Railroad plans a one-story enginehouse at Chicago, Ill., to cost approximately $12,000.

The Norfolk & Western Railway is said to be planning for the early construction of a new enginehouse with repair facilities at Williamson, West Va.

The Chicago Milwaukee & St. Paul Railway contemplate the changing over the steam power plant at Deer Lodge, Mont., to electric power to cost approximately $63,000.

The Chicago & Eastern Railway plans the erection of a machine shop and enginehouse at Evansville, Ind., to cost approximately $500,000.

The Yazoo & Mississippi Valley Railroad is reported to be contemplating the construction of a new locomotive and car repair shop at Vicksburg, Miss.

The Seaboard Air Line Railway is constructing a two-story building at its shops at Portsmouth, Va., to cost approximately $10,000.

The Pittsburgh & Lake Erie Railroad has awarded a contract for the erection of a freighthouse and office building at Ellwood City, Pa., to cost approximately $75,000.

The New York, New Haven & Hartford Railroad has issued a call for bids for the construction of an enginehouse at Fall River, Mass., and for an enginehouse at Lowell, Mass., also for the construction of a one-story concrete machine shop at East Hartford, Conn., to cost approximately $40,000.

The Chicago Rock Island & Pacific Railway has plans for a one-story mechanical and repair shop at Burr Oak, Chicago, to cost approximately $35,000.

The Missouri Pacific Railroad is contemplating the erection of a fifteen-story building in St. Louis to replace its present quarters in the Railway Exchange building.

The New York Central Railroad contemplates the construction of a machine shop at Frankfort, Ind. The building will be 120 by 180 feet, of brick, concrete and steel construction.

The Central of Georgia Railway has awarded a contract for a 150 ton coaling station with a 5,000 ton storage plant at Raymond, Ga., to the Fairbanks, Morse & Company.

The Baltimore & Ohio Railroad plans to spend $15,000,000 in shop and yard improvements. The new shops will replace ones on four division and will be situated on the banks of the Little Calumet River, South Chicago.

The Chicago & Eastern Illinois Railway has plans for auxiliary locomotive and repair shops at Pigeon Creek, near Evansville, Ind., including enginehouse, turntable, machine shops and other buildings to cost approximately $500,000 with equipment.

The Atlantic Coast Line Railroad plans addition including new trackage and storehouse facilities at Rocky Mount, N. C., a locomotive repair shop at Tampa, Fla., a new machine shop at St. Petersburg, Fla.

Items of Personal Interest

W. B. Marshall, formerly acting roadmaster, Norfolk Division, Southern Railway, was promoted to roadmaster, with territory Cincinnati, Ohio, to Danville, Ky., with headquarters at Lexington, Ky. Mr. Marshall entered the service as student apprentice, Danville division, September 12, 1913, and was promoted to section foreman January 1, 1915, assistant track supervisor April 1, 1915, track supervisor January 1, 1916, and acting roadmaster, Norfolk division, May 1, 1926.

E. W. Brown has been appointed superintendent of the Illinois division, New York Central Railroad, with headquarters at Gibson, Ind.

C. M. Barber has been appointed assistant chief special agent for the Missouri Pacific Railroad, with headquarters at Kansas City, to succeed **O. F. Suggs,** who has resigned.

L. R. Stewart, acting assistant road foreman of engines of the Pittsburgh division of the Pennsylvania Railroad, has been appointed assistant road foreman of engines, Pittsburgh division, with headquarters at Altoona, Pa. **C. W. Hawkins** has been appointed assistant road foreman of engines, St. Louis division.

R. W. Rogers has been appointed superintendent of the Georgia division, Seaboard Air Line Railway, with headquarters at Atlanta, Ga.

W. B. Wood has been appointed assistant to the general manager, western region, of the Pennsylvania Railroad, to succeed **J. B. Hutchinson, Jr.,** transferred.

Otto F. Ohlson has been appointed superintendent of the Yellowstone division of the Northern Pacific Railway, with headquarters at Glendive, Mont., and **R. T. Taylor** has been promoted to assistant superintendent of the Montana division, with headquarters at Billings.

Harry Morris has been appointed superintendent fuel and locomotive performance, Central Railroad Company of New Jersey. Mr. Morris was born in Altoona, May 7, 1884. He graduated from Purdue University in Mechanical Engineering with the class of 1907, after which he served an apprenticeship with the Pennsylvania Railroad at Altoona Shops. He entered the service as piece work inspector at Mt. Clare in October, 1914, and was transferred to the fuel department in July, 1925. Mr. Morris resigned to go with the duPont Company in April, 1918, and returned to our service as motive power inspector on the western lines in November, 1919. He was appointed roundhouse foreman at East St. Louis in October, 1924. He served in this capacity until his appointment to the staff of the superintendent, fuel and locomotive performance, in August, 1925, as supervisor train supplies and expenses.

Foster P. Wentz, appointed valuation engineer, Oregon Washington R. R. & Navigation Co. He was born June 30, 1889, at Columbus, Ohio. His engineering education was received at Oregon Agricultural College. In 1912 he joined the engineering staff of the Oregon Electric Railway, then being extended from Salem to Eugene. His next employment was with the Great Northern Railway in construction of the Fairview-Rockford line during the season of 1913. After two other engineering engagements Mr. Wentz became a member of the valuation department staff at Portland, Ore., in March, 1916.

E. H. Lee, vice-president and chief engineer of the Belt Railway of Chicago and of the Chicago & Western Indiana Railway, has been elected president. **J. F. Hogan,** formerly

general freight agent, has been elected vice-president, succeeding E. H. Lee.

Charles W. Shaw has been appointed superintendent of the St. Louis division of the New York Central Railroad, with headquarters at Carbondale, Ill.

H. A. Patterson has been appointed assistant foreman, Meadows enginehouse of the Pennsylvania Railroad.

Henry Shearer has been appointed assistant vice-president and general manager of the Michigan Central Railroad, with headquarters at Detroit, Mich.

M. R. Reed has been appointed acting master mechanic of the Fort Wayne division of the Pennsylvania Railroad, vice **O. C. Wright**, on leave of absence.

E. B. Moffatt has been appointed general superintendent of the Delaware, Lackawanna & Western Railroad, with headquarters at Scranton, Pa., to succeed **H. H. Shepard**, who has resigned.

E. L. Mead has been appointed division engineer, Galena division of the Chicago & North Western Railway, with headquarters at Chicago, **C. H. Wells** has been appointed division engineer of the Black Hill and Wyoming division, with headquarters at Chadron, Neb., to succeed Mr. Mead, and **L. M. Bates** has been made division engineer of the Southern Illinois division, with headquarters at South Pekin, Ill., to succeed Mr. Wells.

E. R. Dowdy has been appointed master mechanic of the Richmond division of the Chesapeake & Ohio Railway, with headquarters at Richmond to succeed **F. B. Moss**, deceased.

Supply Trade Notes

A. D. Neale has been appointed vice-president and **W. W. Harwood** has been appointed assistant to vice-president, in charge of sales, **Canadian Car & Foundry Company** and its subsidiary companies.

The automotive car division of the **J. G. Brill Company**, Philadelphia, Pa., has opened an office in the Railway Exchange Bldg., Chicago, Ill. **A. F. McCormick**, western sales agent, will be in charge.

The Electro Motive Company has opened offices in the Peoples Gas Building, Chicago, Ill., with **J. F. Sattley** in charge.

Announcement has been made of the merger of the **Central Steel Co.**, of Massillon, Ohio, and the **United Alloy Steel Corporation**, of Canton, with assets exceeding $80,000,000, under the name of the **Central Alloy Steel Corporation**. The merger will be effected through an exchange of stock that will give Central Steel common stockholders two and one-eighth shares of new stock and United Alloy common an even share for share exchange. The new board of directors has not yet been announced. **F. J. Griffiths** has been made chairman of the board; **C. E. Stuart**, president and treasurer; **J. H. Schlendorf**, vice-president in charge of sales, and **C. W. Krieg**, secretary.

George E. Watts, formerly connected with the **Duff Manufacturing Company**, has joined the **Timken Detroit Axle Company** as railway representative, with headquarters at Atlanta, Ga.

W. J. Hammond has been appointed traffic manager of the **Inland Steel Company**, to succeed the late **C. L. Lingo**. **Mr. Hammond** has been assistant traffic manager of the Inland Steel Company for the past eight years and formerly was connected with the Illinois Central Railroad in the capacity of contracting freight agent.

L. J. Belnap has been elected president of the **Worthington Pump & Machinery Corporation**, to succeed **C. Philip Coleman**, who has been made chairman of the board.

William M. Neckerman has been appointed assistant to the vice-president of the **Youngstown Sheet & Tube Company**, and in that capacity will be in charge of the tube mill.

The Maintenance Equipment Company, Railway Exchange Building, Chicago, Ill., has been appointed exclusive sales agent in the United States for the Mack reversible switch point protector. The manufacture of this device will be handled by the **Fleming Company**, of Scranton, Pa.

M. F. McConnell, formerly assistant general superintendent, has been appointed general superintendent of the Mingo works of the **Carnegie Steel Co.**, at Mingo Junction, Ohio. Mr. McConnell is succeeded as assistant superintendent by **George W. Vreeland**.

The Keith Car Manufacturing Co. of Sagamore, Mass., has purchased control of the **Standard Tank Car Co.**, Sharon, Pa., builders of tanks for railroad use and steel tanks for storage and other purposes. The latter company also controls the **Standard Transit Co.**, which owns and operates 3,500 tank cars that are leased to oil and railroad companies. The officers of the Keith Company are: **W. J. McKee**, president; **E. A. MacDonald**, secretary and treasurer, and **J. W. Keefe**, auditor. The principal executive office of the company will remain at Sharon, Pa.

Clarence G. Stoll has been elected vice-president of the **Western Electric Co.**, to succeed the late **H. F. Albright**, who held the position for many years. Until his election as vice-president, **Mr. Stoll** was general manager of the manufacturing division of the corporation. His service with the Western Electric Co. dates back to 1903, when immediately after his graduation from Penn State College, he entered the student training school of the company and upon the completion of his course rose rapidly in the executive branch of the apparatus design department, of which he was the head for six years. He was then transferred to the New York plant, where he remained until the outbreak of the World War, in which he served overseas. Since that time he has been operating superintendent, technical superintendent, assistant general superintendent, works manager of the Haythorne plant, and general manager.

Floyd Rose, who resigned as secretary and general manager of sales of the **Heppenstall Forge & Knife Co.**, Pittsburgh, has been elected vice-president of the **Vanadium Alloys Steel Co.**, Latrobe, Pa.

The Roberts & Schaefer Co. has taken over the manufacture and sale of all equipment previously manufactured and sold by the **Car Dumper & Equipment Co.** of Chicago. All uncompleted contracts will be taken over by the Roberts & Schaefer Co. and completed in accordance with the original plans and specifications. The manufacture and sale of all equipment heretofore handled by the Car Dumper & Equipment Co. will be handled for **Roberts & Schaefer Co.** in a department headed by **George N. Simpson**, who was president of the Car-Dumper & Equipment Co.

C. W. Fisher, who has been associated with the **McMyler-Interstate Co.** for two years in the sales engineering department at Cleveland, has been named to head the Chicago branch of that firm. In his capacity as Chicago manager, Mr. Fisher will have charge of engineering and sales for the upper Mississippi district, which includes Illnois, Indiana, Wisconsin, and parts of Mnnesota and Nebraska.

The Kennedy Car Liner & Bag Co., Shelbyville, Ind., recently has purchased a site adoining its factory, which will give it sixty thousand square feet additional working space and make possible an increased production.

The Ohio Brass Co., Mansfield, Ohio, announces a new design of portable resistance type arc welding machine, having connections for 400 to 600 volts with current steps from 30 to 210 amperes.

The New York office of the **Safety Car Heating & Lighting Company** has been moved from 2 Rector Street to 75 West Street, in the new Evening Post building.

The Trumbull Steel Co., Warren, Ohio, has opened a district sales office at 803 Union Trust Building, Cincinnati. **Willard Foster** will be in charge and will handle the distribution of the company's products in southern Ohio, southern Indiana and Kentucky.

The Pullman Company has purchased the twenty-seven acre plant of the **United States Cast Iron Pipe & Foundry Company** at Atlanta, Ga., and will establish a car repair shop there.

W. S. Jones has resigned as vice-president and director of the **Canadian Alloy Steel Company**, Latrobe, Pa.

P. A. Fernsler has been appointed superintendent of coke works, **Pittsburgh Crucible Steel Co.**, Midland, Pa., to succeed **John W. Hacker**, who resigned recently to supervise the construction of a new by-product coke plant for the **Central Steel Corporation**, Massillon, Ohio, of which he will become superintendent upon completion.

Obituary

Senator Albert B. Cummins, of Iowa, died of a heart attack at his home in Des Moines, on July 30 in his seventy-sixth year. Senator Cummins was chairman of the senate interstate commerce committee in 1919, with Representative Esch of Wisconsin they drafted the Transportation Act under which the railroads were returned to private ownership after the war.

Senator Cummins was born near Carmichaels, Pa., February 15, 1850. He entered college but left before the completion of his course. He later studied law and was admitted to the bar in Chicago, but moved to Des Moines to practice as an attorney. He was named by the republicans as an independent candidate for the legislature in 1887 and was elected, serving one term. He was elected Governor of Iowa in January, 1902, and served until 1908, when he was elected to fill the vacancy in the United States senate caused by the death of the Hon. W. B. Allison, and remained in the senate until the time of his death, which came only a few weeks after his recent defeat by Smith W. Brookhart.

He was chairman of the judiciary committee, the ranking member of the interstate commerce committee, and a member of the committee on territories and insular possessions.

Franklin S. Terry, vice-president of the General Electric Company and for years a leader in the incandescent lamp business, died suddenly of heart failure at his summer home at Black Mountain, near Asheville, North Carolina, on July 23. He had been in good health and the week previous to his death attended Camp General, a gathering of General Electric officials, at Association Island, near Henderson Harbor, N. Y.

Mr. Terry was born in Ansonia, Conn., in 1862 and held his first position with the Electrical Supply Company of Ansonia. In 1889 he organized the Incandescent Lamp Company of Chicago and four years later took personal charge of the Company. In 1901 the National Lamp Company, of which he was a founder, purchased the Sunbeam Company. A few years later the National Lamp Company merged with General Electric, Mr. Terry remaining with the National Lamp Works, Nela Park, Cleveland, Ohio. He was one of the organizers of the National Electric Light Association.

He possessed an extraordinary ability for training and developing young men and his qualities as a leader were indicated by the splendid spirit which prevailed throughout his Lamp organization. Mr. Terry devoted his genius as an organizer to the betterment of the manufacture and quality of incandescent lamps until now, as a result, the incandescent lamp industry stands in a class by itself. He was a brother of A. S. Terry, New York, a supervisor of the Incandescent Lamp business of the General Electric Company.

D. E. Spangler, general superintendent of transportation of the Norfolk & Western Railway, died on July 22 at Traymore Hotel, Atlantic City, N. J. while attending the Interstate Commerce Commission hearing on soft coal freight rates. Mr. Spangler was born at Circleville, Ohio, May 21, 1863. He entered railway service in 1879 as clerk for the Scioto Valley Railroad now a part of the Norfolk & Western Railway and subsequently held positions as clerk, telegraph operator, station agent, train dispatcher, chief train dispatcher and car service agent. He was appointed superintendent of transportation October, 1903, and held that position until March, 1920, when he resumed his position as general superintendent of transportation on the Norfolk & Western Railway.

Samuel Brownlee Fisher, consulting engineer of the Missouri-Kansas-Texas Railroad, died July 9, at his home in Parsons, Kans., following a short illness. Mr. Fisher was born at Cherry Fork, Ohio, and was graduated from Washington and Jefferson College, Washington, Pa. He entered railroad service with the Pennsylvania at Pittsburgh, Pa., and worked through all grades in engineering department to assistant engineer same company. In 1885 he was appointed chief engineer of the Everett & Mont Christa Railway. On June 1, 1895 he entered the service of the Missouri-Kansas-Texas Railroad and was appointed chief engineer the following year. He held the latter position until 1912 when he was made chief engineer of construction. When the Valuation Act went into effect he was appointed chairman of the valuation committee. On March 1, 1916, he was appointed consulting engineer and held that position until his death.

New Publications

Books, Bulletins, Catalogues, Etc.

Diesel Engines, by David Louis Jones, instructor, Diesel Engine Department, U. S. Navy Submarine School, 565 pages, 6 in. by 9 in., bound in cloth, illustrated. Published by The Norman W. Henley Publishing Co., 2 West 45th Street, New York City, price $5.00.

This is a practical book, written and compiled by the author with the object of presenting the elementary principles, care and operation of the Diesel engine. It is a complete, thorough and up to date treatise. The first three chapters explain in simple terms the underlying principle of thermo-dynamics and the principle of operation of all types of engines. The constructional features of the engines and such parts at the fuel pumps, fuel injection valves, starting and reversing systems, air compressors, governors, are all treated in detail.

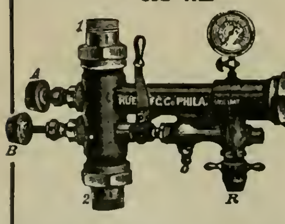
It explains the operation, repairs and maintenance of the Diesel engine, their troubles and adjustments, indicator cards and engine testing.

This is the only American book containing an illustrated chapter on the application of the Diesel engine to railway service. The Diesel engined locomotives are now being operated on a few of the railroads and this book should be in the hands of the supervisory forces and all those who are interested in Diesel locomotives, as it contains data that is invaluable.

Handbook on Railroad Electrification. A pocket size handbook of 96 pages entitled, Railroad Electrification Data, has been released by the Westinghouse Electric & Manufacturing Company.

In Part One of the book has been included sufficient elementary information to make the publication of value to those employes of steam railroads who have not had technical training but who find it necessary to become informed on electric locomotive equipment and its operation. Part Two is composed of information about and diagrams of typical electric locomotives that are now in service throughout the world. Also, there are useful tables of helpful information on steam locomotives, freight cars, train resistance, etc., in this part.

Copies of this handbook, S. P. 1759, may be obtained free of charge from the nearest Westinghouse office or from the Transportation Section, Department of Publicity of the Company at East Pittsburgh, Pa.



Railway and Locomotive Engineering

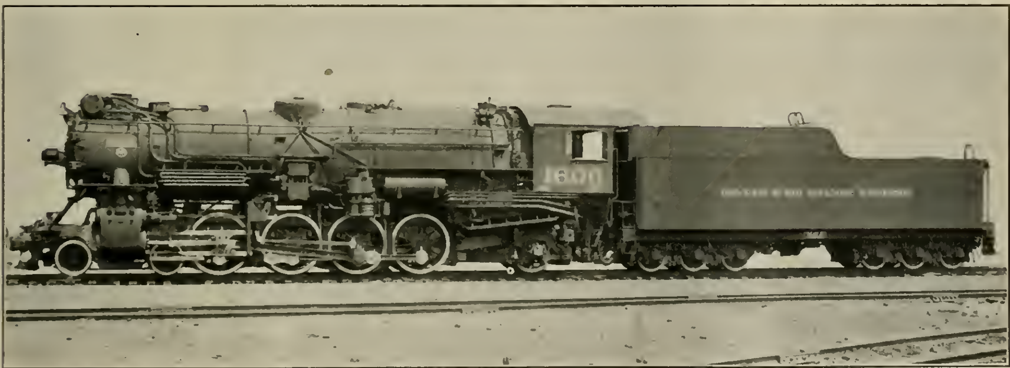
A Practical Journal of Motive Power, Rolling Stock and Appliances

Vol. XXXIX | 136 Liberty Street, New York, September, 1926 | No. 9

Three-Cylinder Mountain Type Locomotives for The Denver & Rio Grande Western Railroad Co.

Built by the Baldwin Locomotive Works for Heavy Passenger Service

The Baldwin Locomotive Works has recently completed ten locomotives of the Mountain (4-8-2) type for the Denver & Rio Grande Western. These locomotives are intended for heavy passenger service under specially severe operating conditions as the maximum grades are three per cent and the sharpest curves 16 degrees. The engines are of the three-cylinder type, and the maximum tractive force of 75,000 pounds, coupled with high steaming capacity, ranks them among the most powerful passenger locomotives thus far built. One of these locomotives was exhibited at the A. R. A. Convention held in June, 1926, at Atlantic City.



Three-Cylinder Mountain Type Locomotive for the Denver & Rio Grande Western Railroad

The boiler, apart from its large dimensions, represents no unusual features of design. It is of the conical type, 92 inches in diameter at the first ring and 104 inches in diameter at the dome course. The firebox is of corresponding size and volume, with a grate area of 94.5 square feet and a combustion chamber five feet long. A brick arch is installed, and is supported on two syphons and three tubes. The locomotives are fitted to burn coal, and are fired with du-Pont-Simplex stokers. They are equipped with feed-water heaters, five locomotives taking the Worthington and five the Elesco.

The three cylinders are cast separate from each other, the middle cylinder being in one piece with the saddle. The front frame rails are single, measuring 6 inches in width by 13½ inches in depth; and the outside cylinders are securely bolted to them, and also to the central cylinder casting. The inside cylinder drives the second pair of wheels and the outside cylinders the third pair; and all three take high pressure steam and have cranks set 120 degrees apart. The two outside cylinders are cast from the same pattern.

The steam chest for the inside cylinder is placed on the right hand side, and receives its steam supply from a branch leading from the right-hand steam pipe. The location of this steam chest makes it necessary to run the exhaust passage for the right hand and the inside cylinders underneath the latter to the left side of the casting, and thence up to the base of the exhaust pipe. All pipe joints subject to live steam pressure are placed outside where they are easily accessible.

The steam distribution to each cylinder is controlled by a 12-inch piston valve having a steam lap of 1⅛ inches and an exhaust clearance of ¼-inch. The valves are set with a travel of 6½ inches and a lead of ¼ inch,

and are operated by Walschaerts gear. The motion on the left side is arranged in the usual way; but on the right hand side the main pin has attached to its a double return crank which operates two links, one for the inside cylinder and the other for the right-hand outside cylinder. The inside valve receives its lead from the corresponding crosshead, and the movement is transmitted from the plane of the latter to that of the outside link through a horizontal shaft which is fulcrumed in a rocker whose bearing is bolted to the main frame. This horizontal shaft passes through a crosshead to which the inside valve stem is attached. The three valve motions are controlled by a power reverse gear.

Three Cylinder Mountain Type 4-8-2 Locomotive

Cylinders		
Clinders (3)	25 x 30 ins.	
Valve	Piston, 12 ins. diam.	
Boiler		
Type	Conical	
Diameter	92 ins.	
Working pressure	210 lbs.	
Fuel	Soft Coal	
Firebox		
Material	Steel	
Staying	Radial	
Length	126⅛ ins.	
Width	108 ins.	
Depth front	96 ins.	
Depth back	73¾ ins.	
Tubes		
Diameter	5½ ins.	2¼ ins.
Number	64	244
Length	19 ft. 6 in.	19 ft. 6 in.
Heating Surface		
Firebox	282 sq. ft.	
Combustion Chamber	120 sq. ft.	
Tubes	4,581 sq. ft.	
Firebrick tubes	25 sq. ft.	
Thermic syphons	85 sq. ft.	
Total	5,093 sq. ft.	
Superheater	1,495 sq. ft.	
Grate area	95 sq. ft.	
Driving Wheels		
Diameter outside	67 ins.	
Diameter center	60 ins.	
Journal	11½ x 14¼ ins.	
Engine Truck Wheels		
Diameter front	36 ins.	
Journals	7 x 14 ins.	
Diameter back	49 ins.	
Journals	9 x 16 ins.	
Wheel base		
Driving	18 ft. 3 ins.	
Rigid	11 ft. 10 ins.	
Total Engine	41 ft. 6 ins.	
Total engine and tender	86 ft. 5 ins.	
Weight in working order		
On driving wheels	290,530 lbs.	
On truck front	67,880 lbs.	
On truck back	60,900 lbs.	
Total engine	419,310 lbs.	
Total engine and tender	716,400 lbs.	
Tender		
Wheels number	Twelve	
Wheels diameter	36 ins.	
Journals	6 x 11 ins.	
Tank capacity	15,000 U. S. gal.	
Fuel	25 tons	
Tractive force	75,000 lbs.	
Service	Passenger	

The outside eccentric rod on the right-hand side has a solid end of the usual design at the back end, while the inside rod necessarily has a split brass, which is held in place by a cap secured by two horizontal bolts.

The outside crossheads are of the Allegator type, while the inside crosshead is of the underhung type, this design being used to provide sufficient clearance above the first driving axle. The outside guides and crossheads are unusually long, and the guides are supported by two bearers, placed respectively ahead of, and behind, the leading drivers. The lips of the inside guide, which take the pressure when backing up, are separate pieces, secured to the broad upper shoe of the guide by vertical bolts. This is a form of construction, which is amply strong and facilitates the machining of the various parts.

The main and side rods are all of carbon vanadium hammered steel, annealed, and are of I-section, and the crank pins are of the same material. Floating bushings are used on the main side rod pins, and also on the back ends of the outside main rods. The back end of the inside main rod is of the strap type.

The crank axle is a product of the Standard Steel Works Company, and is built up, the pin and axle portions being of normalized carbon vanadium steel and the crank cheeks of open hearth carbon steel. The cheeks have bolted to them cast steel counterweights which are filled with lead. The three other driving axles are of carbon vanadium steel.

The leading truck is of the Commonwealth constant resistance type, and the trailing truck is of the Delta type. The arrangement of the spring rigging calls for no special comment.

The tender is one of the largest yet built with a rectangular tank, as it has capacity for 15,000 gallons of water and 25 tons of coal. It is carried on six wheeled trucks. The stoker engine is mounted on the forward end of the tender, instead of on the locomotive, as has been the usual practice heretofore.

The dimensions of the locomotive are given in the accompanying table.

Speed of Freight Movement Faster

Class I railroads in July handled the freight traffic offered them with the greatest expedition and dispatch on record for that month, according to reports just filed by the carriers with the Bureau of Railway Economics.

Not only was it moved faster, these reports showed, but cars were loaded more nearly to capacity which show a continued increase in the efficiency with which freight is being transported.

The daily average movement of freight cars on the steam railroads of this country in July was 30.5 miles, the highest for any July on record. This was an increase of 2.2 miles over the best previous July which was in 1917 and an increase of 2.9 miles over July last year. It also was an increase of 5 miles over July, 1924. Below are the figures for the first seven months of the present year compared with the same months of 1925:

	1926	1925
January	27.5	26.5
February	28.6	26.9
March	29.3	26.4
April	29.0	26.6
May	29.8	27.3
June	30.1	27.4
July	30.5	27.6
Average	29.2	26.9

In computing the average movement per day, account is taken of all freight cars in service, including cars in transit, cars in process of being loaded and unloaded, cars undergoing or awaiting repairs and also on side tracks for which no load is immediately available.

The average load per car in July was 27.6 tons, which, while not a new high record, was an increase of two-fifths of a ton over July last year and four-fifths of a ton over July, 1924. Compared with July, 1923, it was a decrease of nine-tenths of one ton.

Standardization and Interchangeability of Parts Feature Eight New Japanese Electric Passenger Locomotives

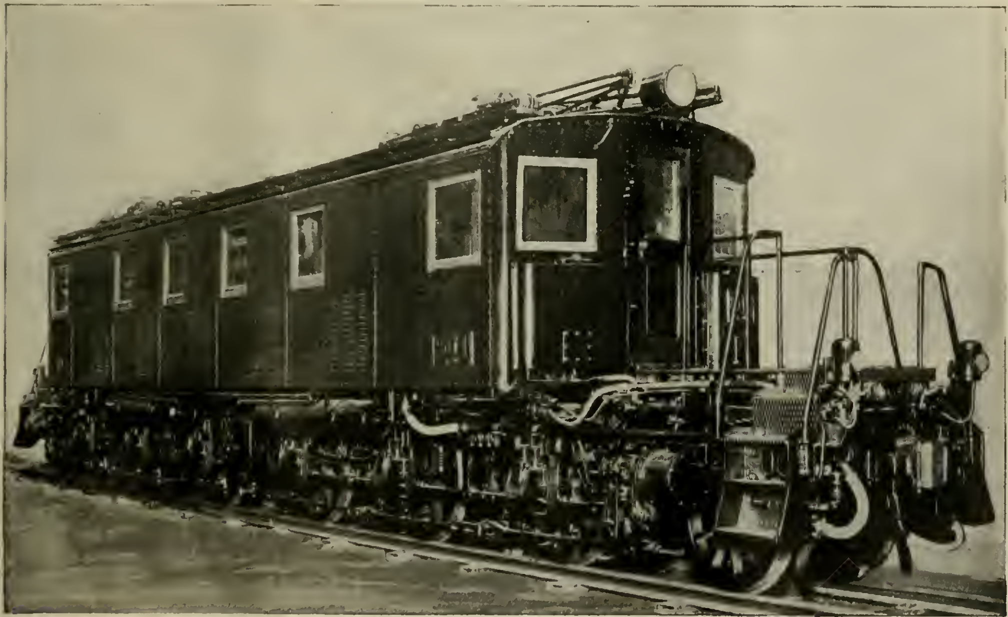
By F. A. Alben and D. M. Palmer, Railway Equipment Engineering Department, Westinghouse Electric & Manufacturing Company

The Imperial Government Railways of Japan has undertaken a project that involves the eventual electrification of some 9,000 miles of track, to enable the more effective handling of the rapidly increasing traffic on its narrow gauge lines. The tokaido line which extends from Tokio through Yokohama to Kobe, a distance of about 375 miles; and the Chuo or central line between Indimachi and Kofu, a distance of about 80 miles, have the heaviest traffic and logically were the first selection for electrification.

In connection with this main line electrification, more than 40 electric locomotives have already been delivered. Particularly for handling the service and meeting the conditions on the two lines mentioned previously, the Imperial Government Railways in 1925 ordered eight more Baldwin-Westinghouse electric high-speed passenger locomotives involving six local and two express service units.

Their design has been worked out carefully to provide the greatest possible degree of standardization of locomotives to meet all local and express passenger service. The idea has been carried to the point where all details of the units excepting cabs, main frames and equalization systems are interchangeable. This feature is greatly desirable from the maintenance standpoint as the variety of stock of spare parts that must be maintained is minimized. By this advanced stage of standardization complete driving units consisting of the motor mounted on the driving axle, and the wheels, can be transferred from one class of unit to another without difficulty.

Each locomotive has a single box-type cab, having an operating compartment at each end and an equipment compartment between them. The articulated trucks have bar-type cast steel frames outside of the drivers, substantially braced by cast steel cross ties and bumpers, and supported by a three-point equalization system on the express passenger class and by a through side equalization on the local passenger class. The cross equalizer on the express passenger type is directly behind the first pair of drivers. Lateral centering devices and spring buffers between the main trucks have been provided to give better riding characteristics. The main truck distribution and stability is obtained from the cab through center pins and cab spring supports. The wheel arrangement is 1C+C1 for the express passenger locomotives and 1B+B1 for the local passenger units.



Electric Locomotive for Express Passenger Service on the Imperial Government Railways of Japan

Flexible heat treated spur gears are used on both types of locomotives. Flexibility is obtained by means of coil springs interposed between the gear rim and center, which tend to cushion sudden impacts on the teeth, and decrease vibratory noises. Standard MCB automatic type couplings have been provided as the Imperial Government Railways is changing from the continental type which was its former standard.

The Westinghouse airbrake equipment is a combination vacuum and air type. The locomotive brakes are controlled by air and the train brakes by the vacuum, but the operation of both is synchronized. Rail guards are attached directly to the truck frames so that they will

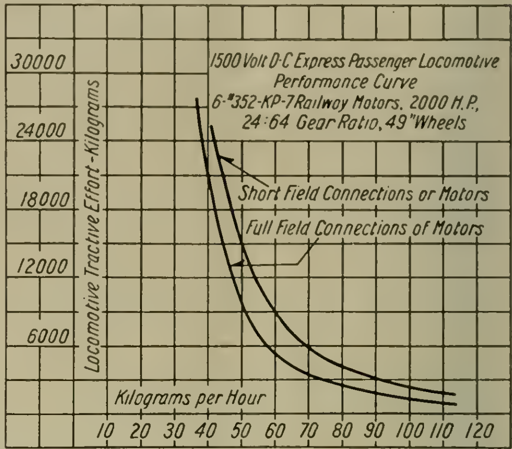
follow the curvature of the track to remove obstacles from the rails. Following are some principal mechanical data for the two types:

	1B + B1	1C + C1
Gauge of track	42 "	42 "
Diameter of driving wheels	49 "	49 "
Diameter of truck wheels	37 "	37 "
Driving wheel base rigid	6' 8 "	13' 4 "
Driving wheel base total	33' 0 "	46' 4 "
Length overall	41' 0 "	54' 4 "
Length of cab	32' 0 "	38' 0 "
Width of cab	9' 1 "	9' 1 "
Height rail to top of cab	11' 3½"	11' 3½"
Height rail to top of cab hatch	11' 6¾"	11' 6¾"
Height rail to closed position pantagraph	12' 10 "	12' 10 "
Journals driving	6" x 9"	6" x 9"
Journals truck	5" x 8"	5" x 8"
Weight of drivers	114,160 lb.	152,540 lb.
Weight on trucks	36,738 lb.	32,720 lb.
Weight Total Locomotive	150,898 lb.	*185,260 lb.
Weight Mechanical Parts	94,575 lb.	111,168 lb.
Weight Electrical Parts	56,323 lb.	74,092 lb.
Couplers	M. C. B.	M. C. B.

*Without sand, tools and equipment compartment doors.

The main traction motors, designed particularly for the Imperial Government Railways, each have a nominal rating of about 333 hp. and embody the characteristics required for the service and the narrow gauge. They are arranged for field control, and force ventilated by two combination blower motor and generator sets. Four motors are used on each local passenger locomotive and six motors on each of the express passenger type. On both types of locomotives the motors are mounted on the axles and directly geared to the drivers with a 64:24 gear ratio. They are arranged to operate two in series on 1500 volts direct current.

The equipment compartment has three sub divisions, the central one of which houses the high tension equipment consisting mainly of accelerating grid resistance, accelerating unit switches, overload protective devices, air operated traction motor reversing mechanism and high tension fuses for the auxiliary circuits. A compartment at one end of the high tension section contains vacuum and airbrake control apparatus, one combination blower and control generator set, one 1500 volt d-c. compressor with a capacity of 50 cu. ft. of free air a minute, a watt-



hour meter, terminal boards for control wires and one battery box containing a 7-cell 60-ampere-hour lead storage battery for energy supply for the control circuits. In a similar compartment at the opposite end of the high tension section are located another combination blower motor and control generator set, a 1500-volt d-c. exhauster (same as compressor except with reverse operation), a 33-volt generator panel for regulating the generator voltage of the two combination sets, a panel for the storage battery, control and light circuits and another 7-cell storage battery which is connected in series with the battery in the compartment at the other end of the cab. Three 1500-volt d.c. hand operated canopy switches on a panel above the combination set in this compartment are used to connect the auxiliary apparatus to the line. One is used for operating the two combination blower-generator sets (the blowers of the two sets are connected in series). The other two switches control the exhauster and the compressor.

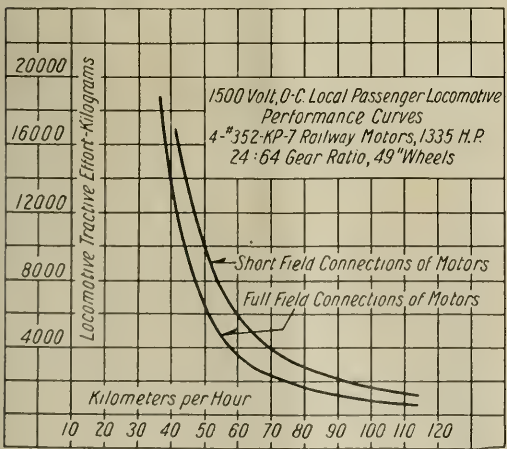

Running Gear and Motors of Electric Locomotive for Express Passenger Service

Each operating compartment contains a meter and gauge panel with control and headlight switches at the top, cab lighting switches in the center and directly beneath them the air gauge and two vacuum gauges, high tension voltmeter and ammeter for the traction motor circuit. A locomotive speed meter is also a part of the equipment. This meter is energized from an electric tachometer which is driven by a runner riding on one of the drivers. It is calibrated to read kilometers an hour for either forward or backward movement of the locomotive.

As left hand drive is standard practice on the Imperial Government Railways, the master controller, brake valves and other operating devices are located on the left hand side of the respective operating compartments. The meter

and gauge panel is located at the right of the engineer. To the extreme left of the engineer is the independent brake valve for controlling the brakes on the locomotive only, or if locomotives are double-headed it will control the brakes on both. The automatic vacuum brake valve is directly in front of the engineer. A foot-operated push button switch for controlling the sanding device through electro-pneumatic valves is easily reached by the engineer's foot. This mechanism also controls the sanders on both locomotives when double-heading. Pantagraphs are raised and lowered by the manipulation of hand-operated push button switches located beneath the window sill at the left of the engineer. When double-heading, all pantagraphs are under the control of one engineer and are raised or lowered in synchronism. The complete layout of both the express and the local passenger locomotives is shown in the accompanying diagram. The cabs are heated with 1500-volt, 1200-watt heaters.

Electric Locomotive for Local Passenger Service on the Imperial Government Railways of Japan



In addition to the two pantagraphs on the roof, there are a lightning arrester and main circuit fuse. Two fuses are used on the express passenger locomotives due to the greater capacity.

Control is of the double-end Westinghouse type HBF. The storage battery supplies current for operating the electro-pneumatic unit switches in the main switching circuit.

The combination blower motor and control generator sets are the same in both types of locomotives, except that the blower fans for the passenger locomotives are slightly larger than those on the local passenger units. However, all sets are interchangeable. The 33-volt control generator on one end of the combination set supplies the energy necessary for charging the storage battery and for lights and control. The armatures are connected in parallel and the two fields in series. A carbon pile in series with the field circuit of the two generators is actuated by a mechanism to maintain 33 volts at the generator armature terminals. While the combination sets are operating the voltage does not exceed 33-volts and when shut down the lighting voltage drops to battery voltage which is approximately 28 volts.

The combination vacuum and airbrake equipment is used to accommodate cars that already are equipped with the vacuum system. The locomotive is controlled by the air brakes which act either independently of or in conjunction with the vacuum brakes. In the latter case the vacuum brakes act as the pilot for the airbrake system.

A 21-inch vacuum is maintained in the vacuum reservoir by a two-speed 1500-volt exhauster. When the locomotive is in operation the exhauster runs continuously at a slow speed. When charging the vacuum train line for release of brakes the exhauster is operated on a short field for high speed. The movement of the handle of the automatic valve from the release position causes the governor to operate, thereby effecting the slow speed connection to the exhauster.

The table above gives some electrical data on both the local passenger and express passenger electric locomotives in service.

	Local Pass.	*Exp. Pass.*
Capacity at One Hour Rating	1350 Volts, 1090 Hp. 1500 Volts, 1250 Hp.	1350 Volts, 1635 Hp. 1500 Volts, 1875 Hp.
Maximum Starting Tractive Effort 25% Adhesion	28,600 lb.	38,200 lb.
Tractive Effort—Hour Rating	1350 Volts, 11900 lb. 1500 Volts, 11900 lb.	1350 Volts, 17850 lb. 1500 Volts, 17850 lb.
Speed—Hourly Rating	1350 Volts, 34.2 mph. 1500 Volts, 38 mph.	1350 Volts, 34.2 mph. 1500 Volts, 38 mph.
Tractive Effort—Continuous Rating	1350 Volts, 7920 lb. 1500 Volts, 7920 lb.	1350 Volts, 11900 lb. 1500 Volts, 11900 lb.
Speed—Continuous Rating	1350 Volts, 40.3 mph. 1500 Volts, 44.7 mph.	1350 Volts, 40.3 mph. 1500 Volts, 44.7 mph.
Maximum Speed	61.14 mph.	68.35 mph.
Type of Conductor	Overhead	Overhead
Number of Motors	4 — 750 Volt	6 — 750 Volt
Gear Ratio	24:64	24:64
Type of Control	HBF Electro-Pneumatic	HBF Elec-Pneumatic

Importance of Motive Power Maintenance*

By A. G. Pack, Chief Inspector, Bureau of Locomotive Inspection, Interstate Commerce Commission

All successful rail activities are dependent upon the smooth and uninterrupted flow of traffic which is possible of attainment only when the motive power measures up to the requirements. The ability to handle future traffic is dependent upon the judgment and foresight of those now guiding the destinies of the railroads by providing proper and sufficient equipment, with shops and tools for maintaining it. To handle the present volume of traffic satisfactorily is also a function of the present management by utilizing the equipment and other facilities with which we are now provided to the greatest possible advantage and herein lies the proof of man's stamina.

It has been my general observation that where motive power and other rolling stock is maintained in a high state of efficiency that the operating efficiency is also high. Wherever we find the condition of locomotive good and in proper compliance with the Locomotive Inspection Law and Rules, dividends are usually being earned, shippers and travelers are better satisfied with the service rendered and a better feeling prevails among the railroad officers and employees.

Teamwork is a wonderful thing and the leader who has the personality to establish an esprit de corps in the organization will go far in bringing in bringing about the most desired results. When men work in unison for a common cause and with a common understanding their efforts are almost irresistible. The trend of the times is toward a higher standard of maintenance and utilization of equipment. The railroads are now confronted with costs undreamed of twenty-five years ago; there, strict attention to every detail is necessary.

The results of the campaign which is being so generally waged toward more effective utilization of railroad facilities is indicated in the Progress Report of the Joint Committee of the Mechanical Division of the A. R. A. on "Utilization of Locomotive" from which is quoted.

"During the year 1925, an average of 158.9 lb. of fuel was required to haul 1,000 tons of freight and equipment, excluding locomotive and tender, a distance of one mile as against an average of 169.9 lb. for the year of 1924. In passenger service an average of 16.10 lb. of fuel was required to haul a passenger train car a distance of one mile as against 16.96 lb. for the year 1924. Had the Class 1 railways would have required an additional 5,596,000 tons of coal in freight service and an additional 1,606,000 tons in passenger service to handle the volume of business offered, making an enormous total of 7,202,000 tons of coal saved in road train service; this being exclusive of having effected in yard service, station service, etc."

It is not my opinion that this saving was entirely brought about by long runs now being generally established, nor by the effort of fuel organizations, nor by the better utilization of motive power, but was largely brought about by the mechanical organization in maintaining the motive power to a higher degree of efficiency than I have ever before known. The compliance with the Locomotive Inspection Law and Rules during this period has been generally better throughout the United States than I have ever before known during my more than fifteen years of experience with the Bureau of Locomotive Inspection.

In the conservation of life and property, my position during the past fifteen years has given me a broad perspective view of it in the country as a whole. Some railroad officers have regarded the passage of laws toward safety as a reflection upon their sincerity and efforts to prevent accidents, and upon their ability in that direction, and as an unnecessary restriction upon their freedom of action. This view may seem to be right and yet time has shown that they are entirely wrong. No one questions the fact that railroad men as a class are actuated by a keen desire to conserve human life and property, but the pressure from sources which need not here be enumerated has been and often is so great that they cannot do what they know should be done.

The railroad organization is comparable to a steam driven high speed machine worked to its capacity with

the pressure ever increasing. Safety laws may be likened to safety valves designed for the purpose of regulating that pressure and to keep it from wrecking the machine. The necessity for such laws is made apparent from a review of the statistics of the Interstate Commerce Commission. For example if we consider the number of accidents which occurred during the three fiscal years ending June 30, 1923, 1924, and 1925, which were caused by the failure of some part or appurtenance of the locomotive and tender, it will be seen that the number of accidents reported during the year 1923 was 1,348 which resulted in the death of 72 persons and the injury of 1,560 others. In 1924 there were 1,005 accidents resulting in the death of 66 persons and the injury of 1,157 others. While during the year 1925 there were 690 accidents resulting in the death of 20 persons and injury of 765 others, or a reduction in the number of fatal accidents in three years of 72 per cent, and the number of personal injuries of 51 per cent.

A further analysis of the statistics of the Interstate Commerce Commission shows that during the period of five years ending December 31, 1925, there were 9,118 passengers and employees killed. While this figure is staggering, the improvement shown by comparison for the five year period ending July 30, 1915, is a strong endorsement for safety first. The number of similar fatalities during the earlier period mentioned was 17,726. These data do not include accidents to trespassers on the right of way nor at grade crossing. Comparison of these data shows a reduction of fatal accidents of 48.5 per cent when comparing the two periods. It is apparent that hazards incident to railroad operation are gradually being reduced notwithstanding the ever increasing volume of traffic being moved. However, we must not be premature in congratulating ourselves on this work. The surface is barely scratched and much remains to be done ere the goal is in sight.

The question of safety of locomotive operation is one that is frequently confronting me. It is my first and greatest duty to conserve human life and limb to the greatest possible extent. It is equally your duty. We may with great enthusiasm improve the efficiency of operation bring about a lower operating, construction and maintenance cost, but if we have failed to properly protect the lives and limbs, and to some extent the destinies of those associated with us in our life work, we have failed miserably in the accomplishment of our mission of doing good. If we can do something that will save the life or limb of a single person, we have accomplished something that cannot be evaluated. Many things have been done to make the locomotive more efficient and safer but much yet remains to be done. When some great disaster occurs, we are stirred into action, but should our efforts be less because the prevailing situation appears fairly satisfactory? The answer is, we must constantly strive for bigger and better accomplishments. It is by evolution that mankind has progressed and we must grow as the world grows, seeking each day to do something of greater value. We cannot stand still. Human nature is so constituted that we must move forward to greater achievements, otherwise we grow stale, inactive, and finally come to ruin. Every day in our lives we observe some condition which if not remedied will sooner or later bring sad results.

If all the deaths and injuries caused by locomotive failures during any single year were the result of a single accident, it would be termed a calamity and would be featured on the front pages of newspapers all over the country; but when they occur one by one they are too often given little thought and consideration, too often considered the result of a natural cause or turn of events incident to the hazard of railroad life. The untimely loss of life or limb of a single person is just as serious to him, his family, and friends as though there had been thousands of others killed or injured at the same time.

I have found that accidents of a particular nature occur at some places which seldom if ever occur at others. They are too scattered to come under the observation of the average individual stationed in any one locality, therefore, the necessity for being ever alert in remedying improper and unsafe practices.

It is well established that locomotive and train operations are hazardous occupations even under the most favorable circumstances. Practically all accidents are chargeabzle to the twin evils of ignorance or carelessness which can be avoided by means known to those who are well informed, barring, of course, the weakness of human nature which is possessed by all to a greater or less degree, to a greater degree by some than others.

The present day leader is chosen because of his knowledge and his ability to lead men, therefore, is particularly adapted to promote the cause of safety and the welfare to a greater or lesser extent of those with whom he is associated. If a man is ignorant of dangers which beset his pathway, it becomes our duty to advise him of such dangers and to teach him by precept and example. The habitual careless, indifferent and reckless man has no place in any profession where the utmost care is necessary.

Frequently when accidents occur they may be traced back to a very minor detail, as minor as the omission of a lock nut or cotter key. A recent experience amply demonstrates the necessity for looking after and guarding against things that are most frequently termed minor and unessential. There occurred a rear-end collision between two passenger trains resulting in the death of 11 passengers and four employees and serious injury of 82 passengers and four employees caused primarily by an air hose on the rear end of the tender on the leading passenger train bursting—defective—which caused the brake to be applied in emergency. It is true that the report indicates that the rear end of the train was not properly protected in accordance with the railroad company's flagging rules and because the engineer of the following train failed to observe the block signal; nevertheless this accident with its terrible result may be traced back to the burst air hose.

You may remember the childhood rhyme beginning, "For the want of a nail the shoe was lost," and tracing the loss of the shoe the loss of the horse, then to the loss of the man, and finally to the loss of a kingdom. It is thus in daily life—the omission of an insignificant duty in the beginning may have a far reaching disastrous effect.

I am a strong believer in the value of personal contact and friendly relations. If we are to obtain the best results and not waste our energy through friction which accomplishes nothing, we must have teamwork—genuine co-operation. In dealing with others, we should give that which we might expect to receive if we were in the other man's place. It has been my constant endeavor to encourage friendly relations between my staff and those with whom they come in contact in the performance of their daily duties to the end that we may arrive at a mutual understanding of the many perplexing questions which constantly arise.

The purpose of the locomotive inspection law can be perhaps no more clearly explained than as expressed in its title. "To promote the safety of employees and travelers upon railroads by compelling common carriers engaged in interstate commerce to equip their locomotives with safe and suitable boilers and appurtenances thereto" which, as you know, has been extended to cover the entire locomotive and tender.

Before concluding, there is one thought to which I would like to invite your most earnest attention, an that is, the direct relation between the maintenance of motive power and the number of accidents which occur. Locomotive failures increase rapidly when appropriations are reduced which necessitate the curtailment of forces and material beyond that necessary to properly maintain the equipment. Correspondingly when appropriations made for the mechanical organizations are raised to a sum ample for maintenance, the failures on the train sheet begin to fade away like snow in the springtime, and the dispatcher decides that this old world isn't such a bad place after all with the equipment available for service.

In its motive power a railroad has certain potential wealth in the form of unused mileage. If any railroad continues to draw on its capital without making restitution in the form of repair work, some day there will come a reckoning and the penalty will be measured in terms of accident and failure reports. My position does not permit me and I have no desire to interfere in the policies of any railroad management, but would like to suggest that money well spent on motive power is insurance which provides against failure in times of stress and is not, as is thought by many men, money wasted.

The Transmission of Power on Oil-Electric Locomotives*

Part II

By Alphonse I. Lipetz, Consulting Engineer, American Locomotive Co.

Differential Elastic-Fluid Transmissions

In the so-called full-power transmissions mentioned in Part I, the total output of the prime mover is always transmitted to the driving wheels through an elastic medium, with the result that, owing to unavoidable losses, only a part of the transferred energy produces useful work. This loss of energy takes place not only at starting, or at low speeds, when a starting device or a transmission is in any event necessary, but also at speeds and torques which otherwise could be easily obtained from the oil engine if it were directly connected with the driving wheels. A full-power transmission would seem to be an unsuitable device for speeds at which it becomes possible to employ the direct drive, as the latter would give a considerable gain in efficiency. Moreover, a main-line locomotive with infrequent stops would, most of the time, run at full speed and would require a comparatively small torque, and only occasionally at starting and on long grades would it require the help of a transmission. It would therefore seem a pity to use a transmission all the time for no other reason than because, for a very small portion of the time, the transmission is indispensable.

A. E. L. Chorlton, of William Beardmore & Co., Glasgow, Scotland, developed a design of a 2-10-2 internal-combustion locomotive consisting of a six-cylinder V-type oil engine with a mechanical transmission and a hydraulic clutch between the engine and the driving wheels. The mechanical transmission provides the increase in torque at starting and permits a direct drive when a certain speed has been attained. The details of the design, however, have never been revealed. A similar scheme has been recently devised by Prof. C. A. Norman. He uses a planetary gear with a hydraulic clutch, which permits a considerable increase in torque at starting with a direct drive at certain speeds.

An excellent solution of the problem is offered by differential transmissions in which a certain portion of the power is transmitted by fluid and the remainder is carried through mechanically, the proportion of the latter part varying from 0 to 1 with the increase of velocity from nothing to full speed. Many designs of this kind have been suggested in the last 20 to 25 years, mostly for automobiles, and some of them are now being developed for locomotives.

The Hall Transmission

Fig. 1 represents two vertical cross sections through the Hall transmission. A is the primary shaft; it drives eccentric R of a multi-cylinder piston pump, the cylinder block C of which is geared to the secondary shaft (not shown on the drawing) by means of wheel G. Cylinder block C constitutes one unit with a multi-cylinder hydraulic motor M, the pistons of which, together with their rods r and eccentric strap s, can rotate around a

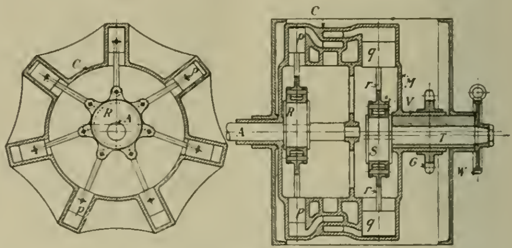


Fig. 1—The Hall Transmission

fixed eccentric S. The actual eccentricity of the latter in relation to the axis of the cylinder block is controlled by a wheel W keyed to a shaft T which can be turned in an eccentric bushing V. The eccentricity of the latter is equal to that of eccentric S. By turning it with shaft T in bushing V, eccentric S can be placed either in line with the prime-mover shaft and the cylinder block, in the other extreme, or in any intermediate position.

The operation of the transmission is as follows: Before starting, shaft A rotates at full speed and drives eccentric R, which moves pistons p in cylinder block C. Motor M with pistons q and gear G is at a standstill. The primary part will now become a full-stroke piston pump generating pressure inside the cylinder block. As the fluid has no other means of coming out than through the cylinders of the secondary part, it will push pistons q as soon as the pressure is sufficient to overcome the resistance of starting. It will then turn wheel G with everything geared to it, thus establishing a continuous flow of liquid through the pump and cylinders. On the other hand, as the speed of wheel G, due to the acceleration of the locomotive, goes up, the relative speed between shaft A and cylinder C of the pump slows down. Let us assume that the cylinder block with wheel G attains a speed of one-sixth that of shaft A. The relative speed of the pump will be only five-sixths of the speed of A, and only five-sixths of the full output of the pump will be discharged into the motor. The cylinders of the motor must thus absorb five-sixths of the full output of the pump, or, as

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Part 1, published in the August, 1926, issue of RAILWAY AND LOCOMOTIVE ENGINEERING.

wheel G rotates six times slower than shaft A, the cylinders of motor M must, during one-sixth of a revolution, sweep a volume five-sixths of the output of the pump, or, during a whole revolution, a volume five times that of the pump. Eccentric disk S must therefore be placed in such a position as to provide the necessary stroke for pistons q. The torque transmitted through motor M is thus five times as large as that directly applied through cylinder block C, and the total torque on wheel G is six times that of shaft A—this as had to be expected, since the speeds are in a ratio of 6 to 1.

As the speed of wheel G increases, the pump delivers less and less fluid. In order to keep the pressure constant and thus balance the constant torque of the engine, it is necessary to turn disk S in accordance with the reduced pump delivery. If we reduce the secondary eccentricity too much we increase the fluid pressure and the torque, and overload the oil engine; conversely, if we increase the secondary eccentricity of S, the events will be reversed and will result in underloading the oil engine. In order to obtain the full power of the oil engine at all speeds, it is necessary to control the eccentricity of disk S in strict accordance with the variation in speed and torque. This can be arranged automatically from the pressure in the pump, and devices of this sort have already been built in connection with a gear of a certain type.

Mechanical Transmissions

The great success of Stephenson's *Rocket*, the prototype of the present-day steam locomotive, must to a very large extent be attributed to the fortunate idea of a direct connection between the steam pistons and wheels. We do not know whether George Stephenson was conscious of the fact that steam, on account of its wonderful flexible properties, does not require, even for variable loads, any other transmission than the direct connection. We know, though, that others were not aware of this fact and that no less a genius than James Watt thought that a variable transmission was indispensable for a steam locomotive. In the description of his invention of a steam locomotive patented in 1784, Watt described a sun-and-planet-wheel transmission and two sets of gears, differing in their proportions, which he provided in order to adapt the power of the locomotive to the variable resistance of the road.

However, Watt did not attempt to build a locomotive, either with the double or with any other transmission, as he very soon lost confidence in the possibility of propelling locomotives with non-condensing engines; and it was left to George Stephenson to prove that it could be done. Stephenson discarded a good many of the prejudices of his age, among them the fear of direct transmission. He tried it, succeeded, and established it as a typical locomotive feature. It is therefore quite natural that present-day locomotive designers are striving to preserve the simplicity of the direct-driven steam locomotive for the oil-engine locomotive. In order to do this they have had to solve the problem of starting and, to a certain extent, that of speed variation. These have not yet been satisfactorily solved, but very interesting attempts to do so have already been made.

The problem of starting can also be solved, especially for small power, in the same way as it is done in automobiles, namely, by starting the oil-engine without load and putting the load on by means of a clutch. This procedure has been considered impracticable for large power, but quite recently the principle has been embodied in a locomotive which will be described later.

We thus see that two possibilities present themselves: one a mechanical transmission with an interposed clutch similar in principle to the ordinary automobile drive, and the other a rigid connection between engine and wheels by means of gears, or rods, or both.

Gear-Clutch Transmission

Gear-clutch transmissions have been in use for a long time in small industrial locomotives and rail cars, mostly in France and in Germany for powers ranging from 30 to 200 hp. They represent a combination of clutches, of a set of gears of the sliding type, of universal joints, and bevel gears. Sometimes chains, jackshafts, and rods are also used. The well-known Renault rail cars and the Deutz and Schneider industrial locomotives employ transmissions of this kind. In this country the McKeen car was at one time very much in vogue. The Baldwin 100-hp. gasoline locomotive, of which several hundred were built during the World War, was provided with a gear-clutch transmission.

In 1923 the Swiss Locomotive Works in Winterthur built a 0-4-0 switching locomotive with four pairs of gears always in mesh and four hydraulically operated friction clutches of the Meyer type (Fig. 2). One gear wheel of each pair is made of two parts which are screwed together and can rotate on the hubs of two inside disks which form the clutch. The disks and wheels have concentric tapered grooves and are pressed against the wheels by hydraulic pressure, which thus engages and disengages the clutches. The disks can slide on the keys by which they are set on the hollow shaft. Normally the disks are kept disengaged by oil which fills the lower passage of the shaft at a constant pressure; when necessary, they are engaged by admitting oil into the upper passage at a pressure in excess of that in the lower passage. The four speeds are: 5, 9½, 15 and 22 m.p.h. Bevel gears are used for reversing.

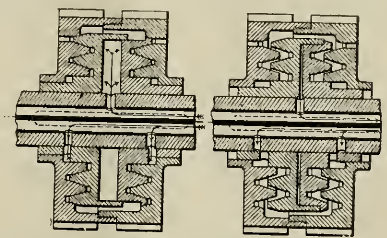

Fig. 2—Meyer Type Hydraulically Operated Friction Clutch

The locomotive weighs 17.9 tons and is driven by a three-cylinder, four-cycle airless-injection oil engine developing 80 b.hp. at 450 r.p.m. Since its completion it has been used for switching service in the yards of the Swiss Locomotive Works, and another locomotive of a larger size with a Meyer clutch is now under consideration.

The most daring application of a gear transmission has been recently made in a 1,000-hp. Diesel locomotive which has been built in the Hohenzollern Locomotive Works in Düsseldorf, Germany. The locomotive has been ordered for main-line service on the Russian Railways in competition with the 1,000-b.hp. oil-electric locomotive previously described. It is of the 4-10-2 type and has a reversible 1,000-b.hp. Diesel engine which acts on a jackshaft by means of three gears always in mesh with three friction clutches operated magnetically. The locomotive and its transmission are shown in Figs. 3 and 4. The oil engine drives shaft C through bevel gears M. An intermediate shaft B is permanently engaged with jackshaft A by means of gears N. Shafts C and B can be connected by clutch I and gears Z_1 (first speed), or clutch II and gears Z_2 (second speed), or clutch III

and gears Z_3 (third speed). Each clutch is integral with one wheel of the corresponding pair of wheels, the other wheel being fastened to one or another intermediate shaft. A powerful friction clutch, also magnetically operated, is interposed between the oil engine and the bevel gear M.

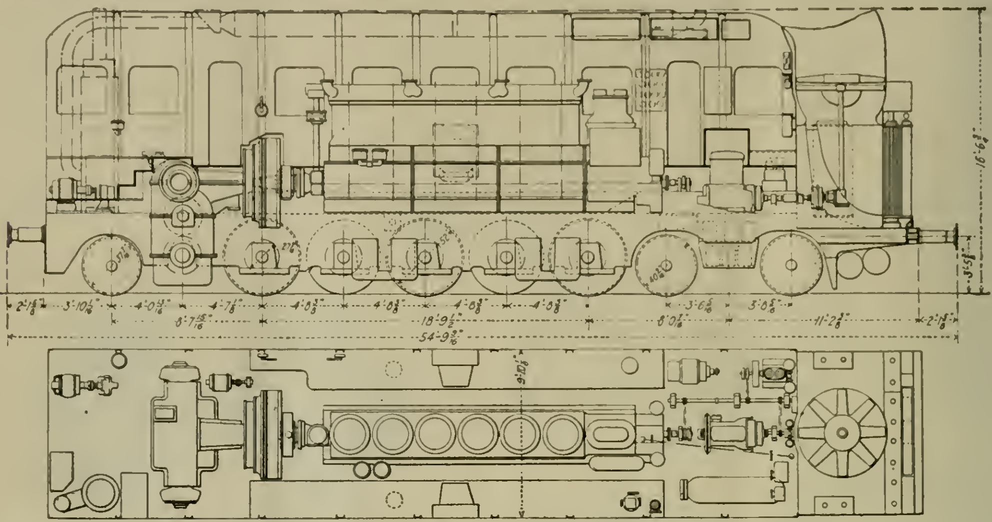

Fig. 3—1,000 Horsepower Diesel Locomotive Built by Hohenzollern Locomotive Works

Thus only three speeds can be obtained at the normal speed of the Diesel engine—three forward and three backward—the Diesel engine being reversible. All intermediate speeds can be obtained by changing the number of revolutions of the Diesel engine itself. In changing from one speed to another, practically half of the total output of the oil engine during the whole period of acceleration will be spent on the destruction of the metal surfaces between the working parts of the respective clutches. However, the builders claim that the wear of the clutches is not appreciable due to the shortness of the acceleration period. The wear of the friction-clutch lining after 1,000 engagings and 2,500 miles of heavy freight service was found to be 0.011 in. Moreover the lining, which is made of special unburnable material, is removable and can be easily replaced by a new one when its wear exceeds 3/16 in. The object of the magnetic operation is to insure a smooth change in speed, and this seems to have been attained during recent tests on the German State Railways.

It is interesting to note the crowded design of the transmission, which hardly permits an increase in power or the addition of a fourth speed.

The locomotive has been already tested on a testing plant and tried out on German Railways, and will soon be shipped to Russia. The results of the actual every-day operation in Russia will be awaited with especial interest.

Direct Drive

In 1913, Sulzer Brothers, of Winterthur, Switzerland, built jointly with Borsig Locomotive Works, of Berlin, Germany, a 4-4-4 1,000-b.hp. Diesel passenger locomotive with a direct connection between the Diesel-engine crankshaft and the driving wheels by means of side rods. Dr. Diesel himself was the designer of the locomotive, and just like Watt, who did not realize the flexibility and adaptability of the steam engine to locomotive drive, did not seem to be fully cognizant of the inflexibility of the Diesel engine and its poor adaptability to locomotives. He tried to solve the problem by using compressed air for starting the locomotive with the train. The engine had to be run with compressed air until the speed of the train reached ignition speed, which for this particular locomotive was 6.6 m.p.h. In order to supply enough starting and accelerating power a separate compressed-air outfit had to be provided. The locomotive was therefore equipped with two Diesel engines—a main engine and an auxiliary engine.

The main engine was a 4-cylinder V-type single-acting, two-cycle engine of 1,000 b.hp. running at 304 r.p.m.

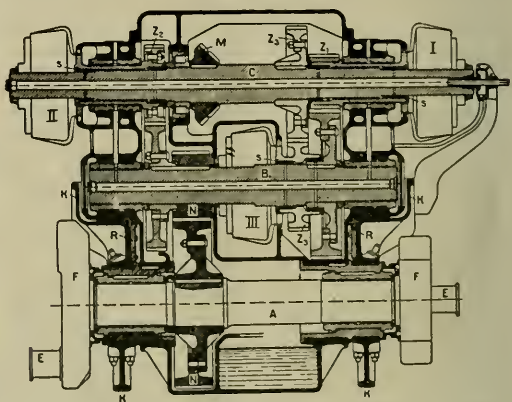

Fig. 4—Transmission for 1,000 Horsepower Diesel Locomotive

The cylinders were 15 in. in diameter by 21⅝ in. stroke and they all acted on one driving (jack) shaft. The engine was reversible and had arrangements for controlling air and oil admission, and it was thought to obtain in this way a means for changing the mean effective pressure in the cylinders in order to meet variable load conditions. During the tests, indicator cards showed a variation of mean effective pressure from 35 to 170 lb. per sq. in., which means, as compared with ordinary two-

cycle engines, a variation of from 40 per cent below to 200 per cent above normal. The auxiliary engine was a vertical two-cylinder, two-cycle engine of 250 hp., cylinders 12 by 15 in., connected with a horizontal multi-stage compressor the object of this combination being to generate air for starting, supercharging, and other purposes.

Starting by air, however, did not give satisfactory results. In order to obtain good efficiencies it was necessary to apply high rates of expansion, which resulted in low temperatures at the end of expansion and cooled the cylinders to such an extent that ignition became impossible. Short expansions, on the other hand, resulted in very low efficiencies and consequently in high consumptions of air which the auxiliary engine was unable to supply. In addition to this, the driving shaft broke at the end of 1913 and was replaced in the spring of 1914, and some other parts also proved to be defective. The locomotive was all the time undergoing repairs and changes; nevertheless several satisfactory runs were made and valuable experimental data were collected, but the work was abruptly stopped at the beginning of the World War. During the war the locomotive was scrapped.

Two direct driven locomotives of considerable size, embodying the Still principles of starting are at present under construction; one is being built in Leeds, England, at the plant of Messrs. Kitson & Co., and another in France, at the works of Schneider & Co. in Creusot. The Still engine is a combination of an oil engine with a steam engine, steam being generated in a separate boiler by the waste heat of the oil engine, and being expanded in the oil-engine cylinder on the other side of the piston. The boiler is placed in communication with the water jackets of the engine cylinders, and thus both the cylinder-jacket heat and the exhaust-gas heat are utilized for steam generated in the Still engine.

Several Still engines have been built for marine propulsion, the latest installation being that on the motorship *Dolius*. It consists of two four-cylinder, two-cycle, single-acting engines, each developing 1,250 b.hp. at 120 r.p.m. Official tests showed fuel consumptions of 0.353 and 0.358 lb. of oil per b.hp.-hr. at full load and three-quarters load, corresponding to thermal efficiencies of 37.1 and 36.4 per cent, respectively.

The Still engine, in addition to its low fuel consumption, offers a very good combination for train starting, steam being an ideal fluid for this purpose. Of course, if the engine has not been run before starting, it becomes necessary to heat the boiler with a specially provided oil burner in order to generate steam for starting. However, in so doing the cylinders are warmed up, ignition is facilitated, and starting on oil is rendered much easier. The presence of a boiler on an oil-engine locomotive may prove to be of great value, as it offers a large amount of stored and available energy, especially with the oil burner in operation, which can be utilized on heavy grades and in emergencies, even though at the sacrifice of fuel economy. There are of course disadvantages to the system, which will be given below.

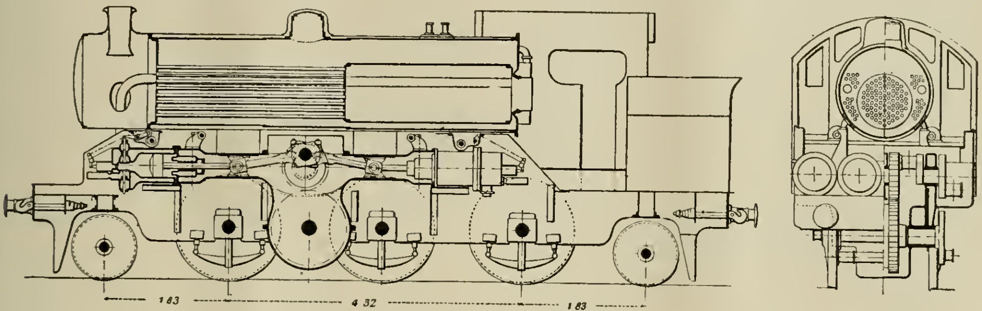

Fig. 5—The Kitson-Still Locomotive

The Kitson-Still locomotive is shown in Fig 5. The oil engine, rated at 1,000 b.hp., is of the four-cycle type and has eight horizontal cylinders driving a four-crank shaft geared to a jackshaft placed underneath the boiler. The latter is of the locomotive type with a modified fire-box. The outside cylinder ends are those of the oil engine, the inside ends being those of the steam engine. Starting takes place through the action of steam on the inside surfaces of all eight pistons. The estimated weight of the locomotive is 77 tons, i.e., 154 lb. per b.hp., or almost the same as in ordinary steam locomotives. The wheel arrangement is 2-6-2 and the total length about 37 ft.

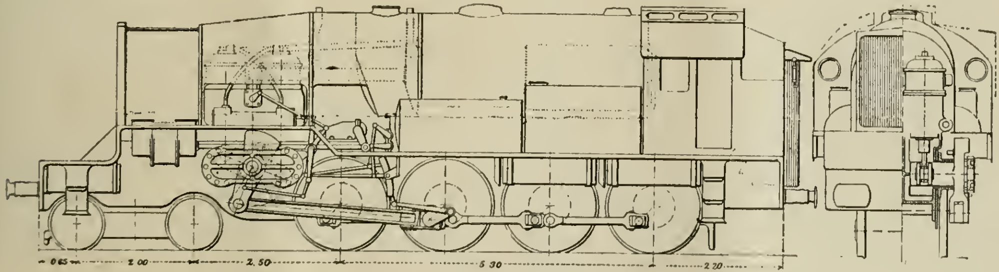
Fig. 6—The Schneider-Still Locomotive

The Schneider-Still locomotive is shown in Fig. 6. It is of the 4-8-0 type, has an overall length about 45 ft. with a rigid wheel-base of 17 ft. 4½ in., and the diameter

of the driving wheels is 5 ft. 2 in. The oil engine was designed as a two-cycle, four-cylinder, vertical engine developing 1,250 b.hp. at 300 r.p.m. The pistons act on three-arm rocking levers connected to ordinary main rods. The boiler is similar to that of the Kitson engine. As the engine is of the two-cycle type and has comparatively smaller pistons, starting of the locomotive is supposed to be effected by using steam on both sides of the pistons. The tractive-effort curves are shown in Fig. 7. *A* is the curve resulting from steam action only, when the oil burner is applied. *B* is the curve of the Still engine (both oil engine and action of steam from waste heat). *C* is the combined tractive effort for overload and emergency conditions, part *D* corresponding to steam action on both sides of pistons. Curves *a*, *b* and *c* represent corresponding power outputs. The estimated weight on the drivers is 141,000 lb. The starting tractive effort would thus give a factor of adhesion of 4.64. The total weight of the locomotive will be in the neighborhood of 100 tons, or 150 lb. per b.hp.

Information received from abroad is to the effect that the oil-engine part of the locomotive has been recently redesigned, the four vertical cylinders having been re-

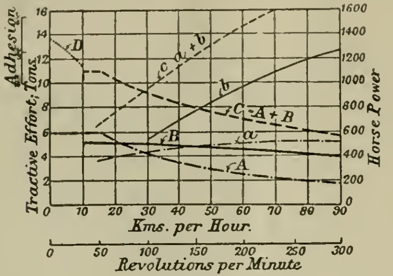

Fig. 7—Tractive-Effort Curves, Schneider-Still Locomotive (From Engineering.)

placed by six horizontal cylinders. Thus the design of the locomotive comes closer to that of the Kitson locomotive.

The two Still locomotives represent a radical departure from previous oil-engine locomotives. A locomotive with a constant-power prime mover and a transmission of this kind described under Class A, B, or C-1 has a hyperbolic speed-tractive-effort characteristic which drops very rapidly with the increase of speed. The locomotives with direct drive (C-2), if at all possible, give a straight-line (constant torque) characteristic with an increase at very low speeds for starting. The steam-locomotive speed-tractive-effort curve lies somewhat between the hyperbola and straight line, and the Still locomotive's curve comes closer to the steam line than that of any other oil-engine locomotive. This is of course its advantage, resulting as do many other advantages from the fact that the Still locomotive is a combination of an oil engine with a steam engine. This combination, however, especially in a locomotive, has its disadvantages; for instance, the realization of tractive efforts beyond certain limits will require the application of the oil burner and will cause a loss in thermal efficiency. The boiler will then be subjected to wear, accumulation of scale, stand-by losses, and maintenance repairs, although to a lesser degree than in ordinary steam locomotives, but nevertheless to an extent depending upon the length of time during which curve *C* (Fig. 7) is used instead of *B*. If steam is very often used at low speeds on heavy grades it may impose on the boiler a great amount of work and result in an appreciable increase in fuel consumption and cost of maintenance. The necessity of using oil for the burner in order to be able to control the fire easily, may not be favored in places where coal is cheap. On the other hand, on level roads, with uniform conditions of traffic, the Still locomotive, especially with passenger through trains, may run for long periods of time on oil with very little steam, and that probably steam which is being generated by waste heat from the oil-engine exhaust.

Further, three other advantages of the oil-engine locomotive proper disappear: the Still locomotive ceases to be smokeless, it is not always available for immediate service, and it requires a certain supply of water. It is true, however, that the latter is partly offset by the possibility of elimination of cooling arrangements, which are not needed on a Still locomotive.

All these points will undoubtedly be cleared up as soon as the locomotives are placed in service, and they will be watched with unabating interest by locomotive and railroad men.

The Pennsylvania Allots $8,000,000 for Safety

Extension of automatic signals and train control devices now being made on the Pennsylvania Railroad involve expenditures totaling $8,000,000. The expenditures being made at this time represent the greatest investment and most extensive installation in signal protection ever undertaken on the Pennsylvania Railroad or any other railroad at one time.

Important new principles to guard against failures in the observance of signals are being worked out by the company in connection with this program. A new device has been designed which consists of electrically operated mechanism by which the indication given by the "wayside" signals—that is the signals displayed on masts at the side of the track or on overhead signal bridges—is duplicated in miniature within the engine cab, keeping the indications continuously before the engineman and fireman.

In addition to the engineman and fireman having continuously before them signals in the cab, each "less favorable" indication by these signals is immediately called to their attention by an audible warning—a whistle which is connected with the signals. There are two sets of signals in the cabs, one on the engineer's side and the other on the fireman's side. Thus, each will receive an identical separate warning.

A train control system involving these cab signals, and what is known as a "stop and forestaller" device, has just been completed on the Pennsylvania Railroad's main line tracks between Harrisburg and Baltimore. This involved the equipping of approximately 150 locomotives with the necessary electrical and mechanical apparatus for the operation of this system, which is actuated by electrical circuits in the track itself.

The present program of the Pennsylvania Railroad for the extension of cab signals and train control covers the main line from Harrisburg to Altoona, the main line from Camden to Atlantic City, the main line of the Panhandle Division from Pittsburgh to Columbus, Ohio, and the main line of the Columbus Division from Columbus to Indianapolis.

When the current program is completed approximately 1,150 engines will be equipped with the cab signals and other control devices, while the necessary electrical apparatus will be applied to 1,530 miles of track.

The "stop and forestaller" is a device so arranged that as a train passes a signal showing any indication except "clear," the air brakes will be automatically applied unless

the engineer "acknowledges" the signal as repeated in the cab by working the "forestalled" controlled by a small lever in the cab. This action "forestalls" the automatic operation of the air brakes, but of course will not be taken unless the engineer has observed the signal and is therefore informed as to the track conditions ahead, permitting him to bring his train under control.

The electrical system adopted in the installation between Harrisburg and Baltimore is limited to three signal indications in the cab. These are "clear," "approach" and "slow." The new plan which has been worked out, and which is known technically as the "coder system," permits four indications, namely, "clear," "approach," "approach-restricting" and "stop." The "approach-restricting" signal is used to show conditions three blocks ahead for which way-side signals are provided on various portions of the railroad. Four signals permit a more complete and satisfactory repetition in the cab of the "way-side" signals than is possible with only three indications.

The Pennsylvania was the first railroad in America to install an interlocking plant for the safe handling of switches and their co-ordination with signals from a central point. It was also the first to use the manual block system of signals. This was in 1863. Nine years later the Pennsylvania was the first to use the closed track circuit, by an installation at Irvineton, Pa.

In 1906, at West Philadelphia, the company employed the first upper quadrant three position signals of the electric-pneumatic type. A year later, between Huntly and Cameron, it was the pioneer in operating the control manual block signal system with continuous track circuit. In 1911 it developed the first three-block signals in the vicinity of Jersey City. A three-block indication tells the engineer the condition of the track for three blocks ahead instead of two, a distance of some miles.

The Pennsylvania Railroad was the first to develop the "position light" signals, in which fixed rows of powerful electric lights took the place of moveable semaphores giving daylight indications, and colored lights giving night indications. The "position light signals" are now used in all new installations and are gradually supplanting the old system.

All of these engineering developments and many others have been completed and successfully developed to make possible the train control device now being installed.

At the present time the Pennsylvania Railroad has 14,355 miles of main track, and all its passenger train service is operated under and protected by the block system, much of which is of the automatic type. Automatic block signals cost more per mile of line protected than any other, and the Pennsylvania Railroad's investment in them is many millions of dollars.

Amplifying System Used in Railroad Switching

The first application of loud speaking telephones to convey instructions to railroad switchtenders on the ground are those just installed at the St. Paul Union Station, St. Paul, Minn., where a public address system is now in use for directing train movements into and out of the terminal.

The application of this device in railroad switching work is said to have greatly increased efficiency of operation by expediting train movements and in reducing the time element required to move trains into and out of the terminal.

At these yards, generally termed "a double bottle neck yard," fourteen switchtenders are employed during the first shift with an average of 250 train movements, while a like number are used on the second shift when the number of movements average 240. Four men operate the switches during the third shift which is called upon to handle about 99 movements in and out.

In the past, signals had to be passed between the switchtenders and train directors either by hand, voice or signal light. With the new method, however, directions are given through the voice amplification system.

The equipment comprises thirty-two loud speaking projectors mounted in groups at seven strategic switching centers. The number of projectors at each location varies in number from two to five depending on the range and area covered. In addition to the projectors in the yard, there is a desk transmitter in the yard director's office, an amplifier for increasing magnitude of the voice current, the current supply apparatus and suitable charging equipment.

Operation of the apparatus for train dispatching purposes is simple. When it is desired to make a call at a time when the yard is not extremely busy, the director throws a toggle switch to the "on" position; this cuts in the filaments and so places the system in operation. Following this he throws the transmitter key to the "on" position and makes the desired announcement. His voice is amplified and the directions issue simultaneously from each of the thirty-two projectors situated at the switching centers.

During rush hours, the system is left in operation at all times so that it is only necessary to throw the transmitter key to the "on" position when it is desired to make an announcement.

The application of these systems to railroad switching work is said to be creating considerable interest among railroad officials of the country.

1925 Census of Steam and Electric Locomotives

The Department of Commerce announces that, according to data collected at the biennial census of manufactures, 1925, the establishments engaged primarily in the manufacture and repair of railroad cars, not including railroad repair shops, built 2,121 steam-railroad cars for passenger service (including baggage, express, and mail cars), valued at $54,940,000; 89,916 steam-railroad cars for freight and other non-passenger service, valued at $184,460,000; 1,624 electric-railroad passenger cars, valued at $15,098,000; and 53 electric-railroad cars for freight and other non-passenger service, valued at $305,000. These establishments also reported products other than cars, to the value of $58,673,000, and repair work valued at $65,031,000. The total value of products $378,507,000, shows a decrease of 37.4 per cent as compared with $604,350,000 in 1923, the last preceding census year.

The combined output of steam and electric railroad cars decreased from 169,688, valued at $396,110,000, in 1923 to 93,714, valued at $254,803,000, in 1925. The rates of decrease in number and value were 44.8 per cent and 35.7 per cent, respectively.

The figures given above do not include data for cars made in steam and electric railroad repair shops and by a few establishments engaged primarily in other industries. The output of cars in 1923 by railroad repair shops and other establishments not engaged primarily in the building of cars comprised 15,062 steam-railroad cars, valued at $24,236,337, and 383 electric-railroad cars, valued at $3,523,648. The corresponding figures for 1925 are not yet available, but will be shown in the final reports of the present census.

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Conservation in Transportation

Since the dawn of civilization conservatism has been the foundation stone on which all great and lasting institutions have been erected. This applies alike to the individual, corporation or state. There is always the possibility that a virtue may, in effect, become a vice and this is particularly true with respect to that class or degree of conservatism that holds its devotees in such a state of precision or uprightness that they sometimes "tip over backwards."

Notable instances of the forementioned condition and its results may be found in the history of individuals and in the field of engineering much damage and serious delay has resulted both from the wildest type of freak schemes and the ultra conservatism that denounced as impossible all suggested improvements regardless of their worth.

The blighting effects of wild speculators and those who were too narrow-minded, stupid or stubborn to recognize the necessity of improvements and adopt them at different stages of progress delayed development in transportation generally.

In 1835, sixteen years after the "Savannah," a partially equipped steamship had made a successful trip from Savannah, Ga., to England, one of the leading, if not the greatest, English-speaking engineer and scientist publicly declared that it was "just as feasible to talk about going to the moon as to talk about crossing the Atlantic in a steamship" The attitude of this man in clinging to his fallacious theories easily delayed marine engineering progress ten or twenty years.

When the automobile first came into use and it was suggested that it might eventually be used to transport passengers and freight commercially, the proposition was received by railway transportation experts in about the same way as were the earlier efforts of John Fitch in applying steam power to water craft. It has been told that two of Fitch's friends on being induced to look over his craft and listening to what they considered his foolish scheme, one said to the other, "poor fellow, what a pity, he is crazy."

The automobile has made such inroads in the transportation field that some of those who fifteen or twenty years ago scoffed at the idea are now actually tumbling over themselves in their mad scramble to get into the motor bus and motor truck game or seeking protection of the courts against the encroachment of a formidable competitor that a short time ago they would not recognize.

Railways are reporting losses on account of bus competition of $1,000,000 to as high as $37,000,000 on individual lines.

Conservatism is a great virtue, and we may well be proud of the fact that our great railway transportation systems are conservatively managed, but we intrude the suggestion that an earlier appreciation of the motor bus and truck as a factor in transportation, would have in all probability, prevented the losses of which they now complain.

The aeronautical engineer is as active today as was ever the railway or marine engineer in their chosen fields and the results will no doubt be as successful and surprising as any past development in transportation either on land or water.

Safety on Rails vs. "Murder on Rails"

The above caption is prompted by an article in the current issue of "The North American Review" under the caption of "Murder on the Rails," which is anonymously signed "Engineer."

The ethics of the engineering profession are of such a high standard that it seems almost inconceivable that a man who gave even scant consideration thereto would by acts of omission or commission stray so far from the facts as is clearly apparent in the article referred to.

There are so many misstatements and failure to include well-known facts pertinent to the subject, that one not only marvels at the reckless audacity of the author, but is somewhat in doubt as to which particular point should be most severely censured.

It is just the kind of vicious propaganda that in years gone by was responsible for poisoning the public mind against corporation interests in general and the railways in particular. Most fair minded people felt that this sort of thing had been pretty well stamped out.

In the opening paragraph of his article the author attempts to create in the mind of his reader a belief that the railways are by acts of omission or commission actually killing or murdering many thousands of innocent, helpless passengers every year, by the use of the following language:

"No one in this wide world is more helpless to protect himself from injury or sudden death than a passenger in a railway train. He pays for and is entitled to expect safe transportation. He is placed in a closed container (as a steel car) where he is as helpless against the effects of collision or derailment as a babe in arms."

Then on the second following page appears the statement that during the time the Interstate Commerce Commission has been investigating the subject from 1906 to 1921, there have been killed in train accidents and collisions a total of 10,978 persons, or an average of about 730 per

year, which the reader is led to believe by the language in his opening paragraph (above quoted) are as helpless to avoid being murdered on the rails as an innocent babe in arms.

Passengers Carried and Killed 1906-1921

In order that this misleading statement may be made clear, the actual number of passengers killed in train accidents, the number carried one mile and the number of passengers carried one mile to one killed is shown in the following table, from which it must be clear to any fair-minded person that travel on American railway trains is far safer than on the streets of our cities:

Year	Passengers Killed in Train Accidents	Passengers Carried One Mile	Passengers Carried One Mile to One Killed
1921	100	37,471,290,688	374,471,686
1920	76	47,276,131,157	622,054,357
1919	98	46,617,943,830	475,693,304
1918	261	43,009,150,651	126,440,423
1917	113	39,739,682,000	351,698,602
1916	181	34,213,596,127	316,292,557
1915	83	32,384,247,563	390,171,657
1914	71	35,258,497,509	496,598,556
1913	141	34,575,872,980	245,218,957
1912	114	33,132,354,783	290,634,691
1911	94	33,201,694,699	353,209,518
1910	179	32,338,496,329	180,661,991
1909	102	29,109,322,589	285,385,515
1908	148	29,082,836,944	196,505,648
1907	367	27,718,554,030	72,802,600
1906	137	25,167,240,881	183,702,488
Total	2,265	560,296,912,760	4,961,452,520

From the foregoing it will be seen that the total passengers killed in 16 years was about 2,265, which is quite different from 10,468 persons mentioned by the author of "Murder on the Rails." It should also be noted that in the most unfavorable period, that of 1907, more than 72,000,000 passengers were carried one mile to one killed, while in the most favorable year the ratio was 622,000,000 passengers carried one mile to one killed.

The total passengers carried one mile during 16 years with only 2,265 killed constitutes a splendid endorsement of the safety of travel on the rails. Anyone imbued with a desire to tell the truth, the whole truth, and nothing but the truth, would not even attempt to go into this matter as the author of the article referred to has done without definitely stating, that, during the 16 years' period mentioned many thousands were killed on our railways that were simply trespassers, for whose death the railways were in nowise responsible.

A casual review of the many millions of new capital put into block signals and train control devices on thousands of miles of our railway, impeaches the statement that improvements of this kind, which tend to greater safety to the public and the employee alike, are persistently opposed by the railways, for with the exception of isolated cases the same is not and has not been the case.

There is a certain degree of responsibility which railway managers must observe with respect to their stewardship of the property in their keeping. In view of the present state of the art if they rushed out and ordered the kinds and type of train control devices now available in sufficient quantity to equip all lines as the author of "Murder on Rails" evidently thinks should be done, the chances are that many of them would soon find they had made a most serious blunder.

Elsewhere in this issue will be found reference to the authorization for the expenditure of $8,000,000 for train control on one of our leading trunk line systems, and in due season other lines will follow, but at the present state of the art there are essential features in the different devices that are not common to all. The actual use or operation of the different types or systems during different climatic or weather conditions over a sufficient period of time to demonstrate their reliability is absolutely essential as a prerequisite to making a selection, and these are features or matters that cannot be handled or disposed of by Congress.

Insult to I. C. C. and Railway Officers

The flat statement that: thousands of helpless passengers who are paying for safe transportation are killed or injured when means to prevent such accidents are available, and that the I. C. C. has itself, aided and abetted the roads in an organized attempt to prevent the installation of train control devices, is not only an unwarranted reflection on the intelligence and honesty of all those who have to do with this important matter, but may be justly termed an open insult.

The Engineer cannot seek or employ the smoke screen of anonymity, or lend himself to the furtherance of political or commercial propaganda, without doing violence to the ethics of his profession. As the article we have criticized smacks sharply of this influence, it fails to impress upon a fair mind as having been inspired by the high and lofty purpose claimed by its author.

Political or commercial interests should find no place in the consideration of a question of such vital importance to the people of this country and any attempt to befog the issue should be severely censured by all fair-minded people.

Cost of Dining Car Service

The operation of the dining car service of railways has been repeatedly referred to in the pages of this publication as a very necessary, but nevertheless, a very costly feature of railway operation in that the revenues from the service do not cover the cost of operation. The service can never be made to pay for itself.

The Pennsylvania system has recently made available some figures as to cost on their lines. The company's dining car service has gradually developed until it now has 152 cars operated on 165 trains.

In 1925 3,907,784 meals were served in Pennsylvania dining cars, an average of 10,700 a day. More than 1,780 persons are employed in the railroad's dining car department.

The average expense of producing a meal on the Pennsylvania Railroad, according to figures offered by the company, ran about $1.48 in 1925. The average receipts per meal were about $1.17, resulting in a loss of a fraction over 30 cents. The deficit from the service was thus about $1,150,000.

Each dining car carries about 1,200 pieces of linen, 510 pieces of silverware and 1,000 pieces of china and crockery. The total cost of one dining car's equipment runs well over $2,500. The cars cost an average of about $40,000. On the Pennsylvania, these factors and the wages of crew and headquarters men combine to produce a cost of 83 cents for each meal exclusive of the food.

The traveling public is constantly criticising railway management for the "high" cost of meals in dining cars, but it never realizes that the service is a constant drain upon the resources of railroads. The operation of dining cars never has shown and never can be made to show an adequate return to the companies for the money that the service costs.

Honesty the Best Policy

The statement has been made on good authority, that "more men are qualified for honorary membership in the Annanias Club through misstatements on railroad matters than any other of the numerous human activities."

The record of achievement of these false prophets embracing as it does apostles of ignorance, stupidity, cunning tricksters, scientific prevaricators, high grade liars, and the plain common garden variety of this latter species.

As a result of the activities of the foregoing battery of "calamity howlers," reputations have been ruined, corporations injured or wrecked, and numerous worthy institutions or projects blasted or seriously impeded in their progress.

In the field of railway activity the evil effects seems to have been more pronounced than in other lines of human endeavor, although it may be safely said that the blighting effect of the scientific prevaricator or common liar is in evidence wherever he may sojourn among men.

Among the many hundreds of instances in which the public mind has been poisoned through false statements with respect to our railways, one of these is again brought to our attention. This particular case comes from the middle west.

Some eighteen years ago a formidable array of these false prophets appeared in the role of lily white defenders of the dear pee-pul of the city of Chicago, to save them from complete destruction from the evil effects of the smoke nuisance, caused by the smoke from locomotives employed on railways entering the city. Different members of the advocates of immediate smoke abatement gave various estimates as to the amount or proportion of the total smoke that was emitted by railway locomotives. These estimates running from 50 to as high as 70 per cent. Practically all these missionaries, however, were agreed on one point, that the railways were responsible for the smoke nuisance, and that they should be compelled by law to commence at once and complete the electrification of all terminals inside of five years under penalty of forfeiture of charter.

When railways officers and neutral experts pointed out that as the railways only burned about 11 per cent of the soft coal used within the city limits, they should not be charged with from 50 to 70 per cent of the smoke nuisance. They also showed that the cost of electrification was not only prohibitive at that time, but that the state of the art had not yet reached a point that would justify such huge additions to their capital account on a matter that was largely experimental. They were given scant courtesy. The anti-railway element, which also included many shady politicians, and was strongly supported by powerful newspaper interests, did not hesitate to grossly misrepresent the facts in this case and thereby poison the public mind.

In order to further the above scheme, a paper was presented before one of the leading engineering societies in Chicago by a man who was supposed to voice the sentiment or policy of the city administration at that time, in which it was alleged that electrification was feasible, practical and economical, and finally that the complete electrification of the Illinois Central Terminals (which line was accused of being the greatest offender) could easily be accomplished for the sum of $8,000,000.

Railway officers and neutral experts at once pointed out, in rebuttal, that the sum mentioned would not at the then prevailing prices pay for the requisite number of electric tractors, to say nothing of the other and greater expenses, and that $20,000,000 to $25,000,000 would be below rather than above the probable cost.

The Illinois Central has recently electrified its Chicago terminal, and although not yet complete in all details and scope of operation, they have so far expended on a job (which the calamity howlers said could be completed for $8,000,000) more than $48,000,000, and the end is not yet.

Of course, the unit prices of labor and material has greatly increased, but, after making full allowance for these, it must be clear to any fair minded student of such matters that the insistent demand for immediate electrification of all Chicago terminals some 18 more years ago, was in the last analysis, an outburst of pernicious propaganda against railway interests, in which truth, honesty, engineering knowledge and plain common sense were subordinated to best serve the interests of those who were actuated by ulterior motives.

Efficiency Record in Use of Fuel

Class I railroads showed the highest efficiency on record in the use of fuel by locomotives during the first six months of this year, according to the Bureau of Railway Economics.

An average of 142 pounds of fuel was required in the first six months in 1926 to haul one thousand tons of freight and equipment, including locomotive and tender, a distance of one mile.

This was the lowest average ever attained by the railroads since the compilation of these reports began in 1920, there having been an average of 144 pounds in the first half of 1925 and 170 pounds in 1923.

Similar efficiency in the conservation of fuel was also realized in the passenger service, the average amount used in that service in the first six months this year having been 16.3 pounds to move each passenger train car a distance of one mile. During the corresponding period in 1925, the average was 16.6 while in 1923 it was 19.2 pounds. In 1920 it was 19.6 pounds.

Below are the comparative figures for the first six months of 1921-1926 inclusive:

	FREIGHT Pounds of coal per 1,000 gross ton-miles	PASSENGER Pounds of coal per passenger-car mile
1921	168	18.3
1922	161	18.0
1923	170	19.2
1924	157	17.7
1925	144	16.6
1926	142	16.3

Class I railroads during the first six months this year utilized for road locomotive fuel a total of 49,935,063 net tons of coal and 990,537,707 gallons of fuel oil. These amounts were somewhat greater than during the corresponding period in 1925, coal consumption being 5.3 per cent greater and fuel oil consumption nine-tenths of one per cent greater. This increase in the aggregate consumption of fuel was due wholly to the increased traffic handled.

Factors contributing to this increased efficiency in fuel consumption by the railroads during the first six months this year included improved locomotives built with a view of increasing the tractive power while at the same time reducing the amount of fuel needed to operate them; educational programs carried on by the various roads to instruct firemen as to the proper method of stoking locomotives and to encourage fuel conservation; closer inspection of coal purchased by the carriers in order to obtain a better grade of fuel than formerly; increase in the length of "runs" of locomotives; and greater expedition in the handling of trains through terminals and also along the lines.

Boiler Corrosion, Pitting and Grooving

Report to Master Boiler Makers' Association

By T. W. Lowe, Canadian Pacific Railway

The Western Lines of the Canadian Pacific Railway comprising over 9,000 miles of territory provide a vast field for research work if we attribute to the water supplies the blame for all the corrosion, pitting and grooving which affects all boilers more or less.

As has been frequently stated the analysis of water by chemists is of great help to them in determining the quality of any one supply, but it does not decide what the analysis of the water is in a boiler at the end of its run, after having evaporated 30,000 or more gallons of water from various supplies, or explain the cause of pitting, etc. The boiler inspector or other officers see the corrosion, pitting and grooving going on continuously in districts where the chemist states the analysis of the water does not cause suspicion. In this vast territory in northwestern Canada we find that in the reputed good water territory there is more serious corrosion, pitting and grooving occurring with the modern design of boiler than was and is experienced with boilers of older design. As a matter of fact many of the original designs of boiler continue to operate in the same district as the modern design without complaint as to a reasonable life being obtained from tubes, superheater flues, staybolts or boiler plate. The brand of material in use over the Canadian Pacific Railway is standard for all boiler construction and repairs. The method of feeding the water is alike on all power, as well as the position of entrance of the water into the boiler. The brick arch equipment is as near alike as the dimensions of the firebox will permit. There are no restrictions as to the general use of any of the water supplies in the good water territory. There are restrictions in bad water districts which necessitate passing up different bad waters which are only to be taken as an emergency.

With these deductions before us, the mysterious part of our investigation begins, because if we decide that oxygen, carbonic, sulphuric or hydrochloric acid as well as galvanic, electric, or any other action is the cause of the corrosion, pitting and grooving which is prevalent, we are confronted with many conflicting experiences in our endeavor to discover a remedy. Chief among them is that the older type of locomotive boiler runs over 20 years without shell repairs and the tubes and superheater flues are fit to safe-end as often as we wish. The modern combustion chamber boiler in freight service has not necessitated any boiler shell repairs in six years, although the life of the tubes and superheater flues is about 75,000 miles. The cause for this short life is because of pitting extending from the front tube sheet in numerous scattered spots for a distance of about eight feet. They groove entirely through the tubes and flues immediately inside the front tube sheet. The pitting and grooving is more extensive on the top of the tubes and flues than the bottom, although not sufficiently excessive on the top to suggest that the action is not general throughout eight feet at the front. The remaining portion of the tubes and flues are normal.

So as the information quoted in this report will be understood I am attaching six drawings, three of which give the analysis of waters spoken of and three of which give particulars of the boilers using these waters.

Sheet 1. Analysis of waters in the northwestern part of Canada where the ground waters are hard and weather conditions very severe in winter. Prairie lands. The samples were taken in February when the water is hard. During spring, summer and autumn analysis of water fluctuates.

Sheet 2. Comprises an analysis of water in the territory of the foothills and over the summit of the Rocky mountains where the ground waters and rivers are not as hard as on the prairie, the weather in winter being less severe than on the prairie. Analysis of water taken during any time of the year does not show much change.

Sheet 3. Includes the analysis of one water supply on the Maple Creek subdivision and the analysis of the water removed from the try-cock of a yard engine just prior to a weekly washout having used that source of supply without having used other waters.

Sheet 4. Particulars of passenger and freight engine boilers running in districts where sheet No. 1 water is used.

Sheet 5. Particulars of passenger and freight engine boilers using water shown on sheet 2.

Sheet 6. Particulars of yard engine boiler using water shown on sheet 3.

Excessive corrosion, pitting and grooving do not accompany the use of water shown on sheet 1, excepting when we permit leaks to ooze from the tubes and staybolts following the removal of the fire. Leaks result in the plates being grooved or channelled out where the water runs over them. Hydrochloric acid is the attacking agent. To prevent this we keep the staybolts free from scale ferrules in the water space by using chemicals, blowing down through the blow-off cocks and a hammering process which prevents scale formation and reduces leakage. By these methods we obtain about five years' good service before the renewal of freight engine fireboxes, and the body of the tubes and superheater flues can be successfully safe-ended six times. The boiler shell using sheeted water grooves out immediately under the root of the front tube sheet as far as the tubes extend. The root of the front tube sheet flange is affected similarly for the same distance. Considerable corrosion and pitting takes place in this sheet above and among the nest of tube holes, but as its life and that of the shell of the boiler under it is about 12 years we do not consider this serious. The greatest harm resulting from the use of sheet 1 water is its scale forming properties, and the reason it is referred to under this topic is that we may profit from the comparison of this hard water with other waters in use such as shown on sheet 2, which are pronounced good. Sheet 2 water, which analysis as good, pits, corrodes and causes grooving in a certain design of boilers far in excess of what occurs using sheet 1 water which is referred to as hard. The G-2, G-4 and D-10 engines using sheet 1 water do not differ as regards the extent of the corrosion, pitting and grooving to be recorable.

The S-2 locomotives using sheet 2 water are excessive tube and flue pitters. The pitting extends from the front tube sheet about eight feet back and is more prominent at the top of the flues than the bottom. Tubes and flues in this class of power necessitate the engines being shopped in advance of machinery repairs on account of pitting and grooving causing the tubes and flues to fail immediately inside the front tube sheet. The mileage of failure fluctuates between 50,000 and 75,000 miles. Slight pitting and grooving occur in the front tube sheet above the tubes, and on the crown sheet surrounding the radial

bolts as well as between the rivets joining it and the tube sheet. At each renewal of tubes and flues about 65 per cent of them have to be scrapped. During five years life no firebox or boiler plate renewals have been necessitated. The G-4 boiler become similarly affected except that it runs its machinery dates before shopping.

The D-9 boilers using sheet 2 water are not affected by corrosion pitting and grooving to any extent. Tubes and flues give sufficient life to allow the application of as many safe-ends as we desire, and although the boiler shells and outside firebox are over 20 years old no renewal have been necessitated. Front tube sheets groove around the heel of the flange and are renewed about every 10 years. We still are experimenting to determine why the modern boilers on the G-4 and S-2 engines corrode, pit and groove so seriously, whereas the D-9 boilers scarcely suffer, although they all operate under similar condition, using the same water supplies with identical methods of feeding the water.

The experience with tubes on a V-1 engine using water shown on sheet 3 is that they had to be scrapped every general repair. The analysis of the raw water supply in use did not altogether show why we experience such serious results. To determine what did, we extracted sufficient water from the top try cock of the boiler just prior to the weekly washout and had it analyzed with a view of knowing if the concentration caused by the evaporation of a week's use of this supply was sufficient to show in the analysis what was happening, and if it did, what the cost would be to neutralize it. Comparing the two analyses shown on sheet 3 will make it clear why a prominent chemist wrote about them as follows:

"I am afraid I did not make it quite clear to you just exactly what happened in the case of the water removed from a switch engine boiler following a week's service when I said that some of this sodium chloride may exist as magnesium chloride, although the analysis only shows the presence of sodium chloride. But in this water even when cold and contained in an iron vessel such as a boiler, a change over of the iron takes place. The magnesium sulphate giving up its S.O. 4 and forming sodium sulphate, while the chlorine from the sodium chloride unites with the magnesium. When this is heated a further disassociation take place, the magnesium chloride parts with some of its chlorine to form free hydrochloric acid which attacks the iron of the boiler causing corroding and pitting, and as this hydrochloric acid after attacking the iron is split up into hydrogen and chlorine the chlorine again unites with the magnesium and thus is ready for further disassociation into magnesium and hydrochloric acid, and thus a vicous cycle is set up in the boiler and the addition of any fresh water from this source only tends to concentrate the hydrochloric acid in the boiler. It is possible to partially neutralize the action of the water but I am afraid not completely, and the reagent to use would prove rather expensive. Barium hydroxide will precipitate all the sulphates and the addition of a little soda ash would precipitate most of the magnesium and calcium. Cost of treatment using these two reagents thirty to thirty-five cents per thousand gallons alone."

The accuracy of the chemist's writings were fully discussed at the time with the result that we adopted a systematic blowing out of the concentrates accompanied with more frequent washing out. This brought about normal conditions. The cost of treatment suggested was prohibitive, and particularly so when the action was not predicted to be completely neutralized even at the expense quoted. Digesting this the prominent chemist quoted remarks still further:

"It appears to me that we too often speak of the origin of the trouble as being the raw water supplies, whereas we require to consider the change occuring to the different supplies when they become mixed under evaporating conditions such as exist in a locomotive boiler. If these be our conclusions we should put into practice the determining and regulating of the frequency of washouts and systematic blowing out of the boilers from the analysis of the water in the boiler at the end of the runs. We know the boiler is a 'chemical laboratory' and yet we leave it to the boiler maker to regulate the period between washouts. It should be a chemist's job to know when the water in the boiler requires changing and a boiler maker's job to know when the boiler is dirty enough to require washing out. The boiler maker knows the boiler is due for a washout before the mud and scale approaches the tube closest to the shell of the boiler because when allowed to gather higher between washouts a blockade occurs which holds over it all future precipitants resulting in tube renewal early. The firebox may only have a couple of hundred square feet of heating surface and the tubes and flues a couple of thousand square feet. This comparison is given to show how wrong it is to say boilers do not require washing out when they have only three inch deposits of scale and mud over the ring because that might mean 10 or 12 inches in the shell of the boiler where the space is limited to three or four inches between the flues and the shell. Analysis of the water in the boiler after each trip is the only true and accurate way of determining the harm that can result from an insufficiency of blowing out or washing out."

I venture to suggest that when a chemist sets the periods between washouts many will find it necessary to perform twice the washing out they now do. This will be profitable in the ratio of spending one dollar to save five because it will reduce pitting, economize on fuel and provide better operating conditions.

The advent of the modern boiler as well as the increased complaint about abnormal grooving, pitting and corrosion are growing up together. The former a good healthy progressive development and the latter the most vicious and detrimental agent which can attack its successful progress.

In my opinion it is wrong to say that the modern boiler inherits this corrosion, pitting and grooving disease because of its size. We have not given its care enough thought and when we do the mystery which veiled our vision and lead us to believe that it is everything under the sun except what we are quite capable of remedying will be lifted and the modern boiler will then be found to function normally.

The advocates of extended periods between washouts with the use of treated waters either internal or external of the boiler are the worst enemies the modern locomotive boiler has today. Their intentions may be good but they have not yet attained that promised state of efficiency which was prophesied with their undertakings, and while I admit the boilers operate more successfully, are more free from scale building and leakage, this has been accomplished with greater destruction to boilers, flues and tubes by the fact that corrosion, pitting and grooving has increased.

Changing the position of feeding the boiler from the side to the top reduced the pitting in the shell of the boiler and increased tube and flue pitting. Our experience is that we should endeavor to favor the shell of the boiler with immunity from this action because of an allowance of four years between internal inspections. A pitted flue will expose itself without inconvenience and seldom results in a service failure.

The cleaner the flues are kept under the entrance of the feed water frequently determines the extent of the pitting to the flues. It is considered good practice to collect the precipitants at this location on a pan suspended above the flues.

The grooving attacking the flues in combustion chamber boilers immediately inside the front tube sheet affects them alike in all waters, with the exception that the failure occurs about three times as early where the water contains hardness and reagents are used. Our conclusion about this grooving of flues inside the front tube sheets is that it will cease altogether when the combustion chamber is prevented from moving towards the firebox due to expansion. This is best accomplished by applying stays to the shell of the boiler and chamber. To be of any value they must be in tension which necessitates connecting them to the shell of the boiler ahead of the chamber. Their application will decrease the breakage of staybolts in the chambers.

Some years ago the Canadian Pacific Railway built a Mallet engine boiler with an intermediate chamber spaced between two sections of flues. From inquiries we received when it was in operation it would appear that other railroads were experiencing very severe pitting of flues in the front section of the boiler whereas the Canadian Pacific had freedom. The only known difference in their construction was that the Canadian Pacific used external circulating pipes for the purpose of connecting the front portion of the boiler with the rear portion which other railways connected differently. It seems proper for me to suggest that the pitting occurring with the modern boiler will be arrested and cured with the application of external circulating pipes. The modern boilers are in need of external by-pass circulating pipes with their long boilers because of the much greater efficiency now developed from the firebox which produces a very violent tide or flow of water and impurities against the front tube sheet where it becomes concentrated, sluggish and out of circulation.

The only reason I know why pitting has increased with the use of treated water is because it has been accompanied with extended periods between washouts. It is very true that we all desire clean boilers and extended periods between washouts bcause that is the acmevement we aim for with treated water. Let me remind you that the constant analysis of the water after treatment by chemists is to teach us that insofar as the treated supplies are concerned the boiler will not be harmed due to extended periods between washouts. My contention is that the chemists should arrive at such conclusions only following the anylsis of water removed from the water at the end of the runs. This procedure will expose the concentration as well as permit all of us to decide which is the more profitable—frequency of washouts, or the purchase of inhibitives. The executives of the railroads must decide this for themselves.

During my long experience over the Western Lines of the Canadian Pacific I have always been a strong advocate of building up a chain of hot water washing out systems for the purpose of performing frequency of washouts, to meet the ever increasing necessities of modern power, to develop economical efficiency, and avoid concentration of water and foaming. The good results we have obtained where they are located is one of the strongest recommendations in their favor, because frequency of washouts has been decided to be the determining factor as to the extent of pitting discovered. Let us then keep down the concentration of salts which are the creation of pitting by the most profitable means we can employ.

Summed up, my experience recommends the following as productive of good results to arrest corrosion, pitting and grooving:

(*a*) Raw water which analyzes as a pitter should not be used under any circumstances to feed steam boilers.

(*b*) The chemists should advise the regulation period between washouts from the analysis of the water taken from boilers at the end of the run.

(*c*) The boiler maker should decide when the boiler is dirty enough to require washing out.

(*d*) When feed water enters the boiler at the top use a pan to collect the impurities.

(*e*) Apply "tension stays" to combustion chamber boilers as described to prevent grooving inside of front tube sheets.

(*f*) Apply external by-pass circulating pipes to modern boilers which are afflicted with pitting.

(*g*) Adopt systematic blowing out to relieve the concentration of salts.

Discussion on Boiler Corrosion, Pitting and Grooving

By C. H. Koyl, Engineer Water Service,

Chicago, Milwaukee & St. Paul Railway

We are not worried about pitting in acid water because everyone knows that acid will attack iron, and it is a simple matter to neutralize the acid with caustic or carbonate of soda (soda ash.) But our troubles commence when it is learned that boilers pit just as badly in alkali water which contains no acid except the weak carbonic, and the troubles are intensified when we learn that boilers pit in waters which have been softened and freed from the last trace of even carbonic acid.

For 10 years our efforts have been concentrated on the study of pitting in alkali and neutral waters. And because these words are used with different meanings in various other chemical studies, please note that in pitting studies "alkali water" means water containing sodium sulphate or chloride, "alkaline water" means water containing sodium carbonate or caustic, and "neutral water" means water which is practically free from mineral matter and contains only a little dissolved air, like the water of mountain streams. These definitions are not strictly chemical but are the terms in common use among boiler men who are studying pitting.

It has been known for a long time that there is a tendency to electric current between any two different metals immersed in water, and that sodium sulphate and sodium chloride dissolved in water make it an electrolyte, that is, make it easy for electric currents to travel through the water. It is also known that the surfaces of steel tubes are not strictly uniform either chemically or physically and that there is a tendency to electric current between, say, the hard spots and the soft spots, and particularly from points where the steel has been strained by stretching or bending, as at the front ends of tubes just inside the front tube sheet and at lines on the firebox.

When these statements of fact were brought together, there resulted the theory that pitting in alkali water is the result of inequalities in the steel, and this explanation was accepted for several years; but about six years ago it was noticed that in alkali waters which have been softened, boiler pitting commences at the front end of the boiler where the water enters and seldom extends further back than the middle of the boiler, and it was noticed also that where switch engines pitted badly in eight months stationary boilers with open feedwater heaters easily lasted four years.

These discoveries made it evident that while pitting is originated by electrolytic action yet it cannot make much headway unless there is something in the water which is taken out by an open feedwater heater, and which in a locomotive is forced into the steam space by the time the water is half way back to the firebox. This substance proved to be the oxygen of the air which is found in all open water and which can be forced out of the water by bringing it to the boiling point for a few minutes. The reasons why oxygen is necessary to the pitting operation are two:

First, when an atom of iron leaves a flue it is dissolved in the surrounding water, just as a small particle of sugar or common salt would be. Water can hold in solution large quantities of sugar or salt, but when it is saturated with sugar or salt and can dissolve no more the remaining sugar or salt continues as a solid body in the bottom of the glass and is permanently safe from solution. Just so when the water in a boiler is saturated with iron (which is in a few minutes) the remainder of the flue is permanently safe from solution and pitting, unless something can take the iron out of the water and thus make room for more. This is exactly what the oxygen in the water does, by combining chemically with the iron to form oxide of iron (plain iron rust) which settles to the bottom and leaves room for the solution of more iron. Therefore, if oxygen can be kept out of the water the process of solution or pitting would be very short lived.

Second, when an atom of iron dissolves in water a corresponding atom of hydrogen is released from solution. These atoms of hydrogen are so small that they do not rise through the water in bubbles but attach themselves to the flue, and soon cover the flue with a thin skin which protects the iron from further solution. But here again oxygen, if present, combines with the hydrogen to form water, and so takes away the coat which would have protected the iron against further solution.

For these two reasons, oxygen must be kept out of water which is to be used in boilers, and if kept out the boilers will not pit unless there is acid in the water.

Many persons have tested it on stationary boilers and have stopped practically all pitting by the use of open feedwater heaters; and the principal advance of this year has been the proof that pitting on locomotive boilers can be stopped by the same means.

With the cooperation of the motive power department we fitted up a locomotive on the Chicago, Milwaukee & St. Paul Railway in January, 1925, and have had it in use for a year on a bad pitting district. This engine and a mate to it were fitted with new flues and put to work on through-freights on a treated water district where the pitting is still bad. The two engines have done the same work and were alike in all respects save that one had an open feedwater heater and the other not. In January of this year it was necessary to remove all tubes from the mate engine because of corrosion under the copper ferrules, and 25 of these tubes were so badly pitted on the front half that they were scrapped. But on the engine with the feedwater heater the tubes were practically as good as new.

In making such a test it is necessary that everyone concerned should know what is being done, so that the injector shall not be used, so that water shall not be taken when standing at stations when there is no exhaust steam, nor when drifting down hill when the exhaust steam is not enough to heat the water. Also the locomotive open feedwater heater must be fitted with a live steam connection to cover such cases; and, because the demand for water is very heavy in hill climbing, the size of the feedwater heater should be determined by this and not by the average demand.

In this locomotive heater the height of water is controlled by a sliding valve which sometimes gets stuck on its rod because of a little scale attached to the rod, and when this happens it sometimes results that the heater fills with water (even escaping from the air vent) and leaves no room for the separation of the air from the water by the heat of the steam. This should always be watched if the heater is used to prevent pitting.

Though no one else has reported any diminution of pitting from the use of this open feedwater heater, I am convinced that it is thoroughly effective in any treated water district, and almost certainly on any alkali water district, if these essentials are attended to. I say again that the days of boiler pitting are nearly over. We are advancing the frontier of boiler knowledge.

Does Railroad Passenger Service Pay?

Members of the general public have frequently expressed skepticism at statements from railroad men to the effect that there was very little profit in passenger service. It is now possible to present the facts regarding 1925 from an impartial source; namely, a *Report on Unit Costs of Railroad Service*, 1915-1925, presented to the Interstate Commerce Commission by Dr. M. O. Lorenz, its Director of Statistics, and just issued by the Commission.

The year 1925 was a year of record-breaking traffic. Out of gross revenues approximating $6,120,000,000, passenger service produced revenues amounting to $1,424,000,000.

This figure included not only all the sums received as fares from passengers, but about $150,000,000 for express matter and nearly $100,000,000 for mail matter carried on passenger trains.

The operation of these passenger trains took $1,219,000,000 of railway operating expenses, and $94,000,000 of railroad taxes, leaving a net operating income of $111,207,000.

A comparison of the passenger service and the freight service of the railroads for the year 1925 shows the following:

	Passenger	Freight	Total
Railway operating revenues	$1,424,967,000	$4,695,636,000	$6,120,603,000
Railway operating expenses	1,219,529,000	3,421,277,000	4,640,806,000
Railway tax accruals	94,231,000	264,268,000	358,499,000
Net railway operating income	111,207,000	1,010,091,000	1,121,298,000

Passenger service produced approximately one-eleventh, and freight service ten-elevenths of the net operating income of 1925.

If the revenue derived from the transportation of express matter were taken away, passenger service would show a loss of $40,000,000 or more.

If the revenue derived from the hauling of the mails were taken away, passenger service would show practically no profit whatever.

If the revenue received from the Pullman surcharge (about $42,000,000) were taken away, it would cut off more than one-third of the small profit now realized on the total passenger service of the American railways.

The Virginian Inaugurates Operation Over Entire Electrified Zone

By E. I. Staples, General Engineer, Westinghouse Electric & Manufacturing Co.

Operation of tonnage trains over the entire electrified zone on the Virginian commenced this week. The electrification now extends from Mullens, W. Va. to Roanoke, Va., a route distance of 133 miles. The initial section from Mullens to Princeton has now been in operation about a year.

The 11,000-volt alternating current system was selected for this electrification and the system layout was based on twelve and one half million tons of coal annually, hauled east from Europe. The initial locomotive order of 36 motive power units was intended to handle 8 million tons annually.

A power plant, owned and operated by the railway, and located at Narrows, Va. contains four 12,500-kv-a. 25-cycle, single-phase turbo generators. There are five water tube boilers with provision for a sixth, each rated at 1521 b.h.p. Pulverized fuel is burned and this system of firing has been found well adapted to rapidly fluctuating loads.

From the generators, power passes through four 10,000 kv-a. oil-insulated, water-cooled transformers which raise the potential from 9,800 volts to 88,000 volts. Two transmission lines run east and west from the 88,000-volt bus, to which the high tension windings of the transformers are connected. Seven transformer stations are located along the right-of-way. The transformers in these stations are known as three-coil transformers; the high-voltage winding is connected to the 88-kilo volt line in the ordinary way, but the low voltage is divided into two parts. One of the low-voltage windings produces 11,000 volts and is connected between the trolley and the rail. The other winding feeds a feeder-rail circuit at 22,000 volts. The potential between the feeder and the trolley wire is thus 33,000 volts. The trolley rail windings of all transformers are arranged for reconnection at 22,000 volts when the increased traffic demands of the railway require the higher trolley voltage.

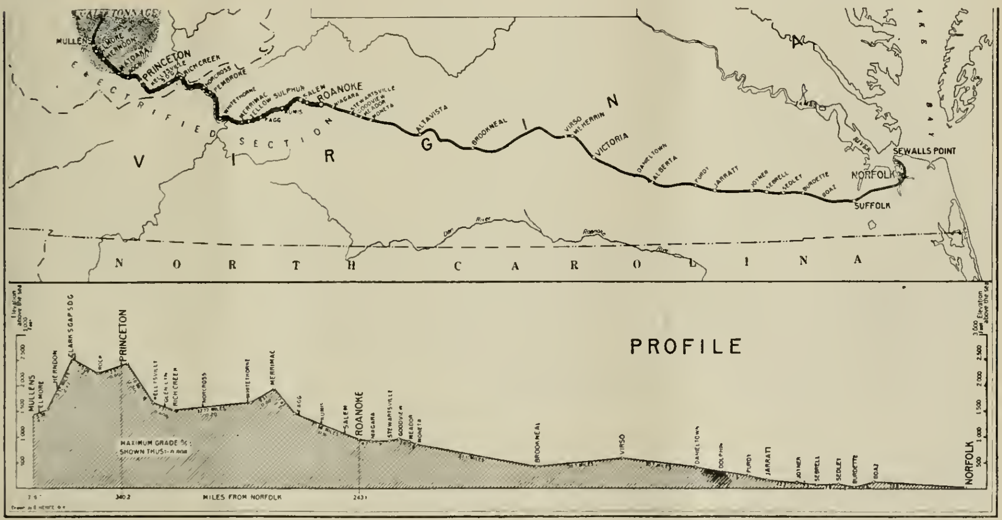
At points between the main transformer stations are placed balancer stations which contain auto-transformers. These are connected between the trolley and balance wires with a point on the winding corresponding to 11,000 volts from the trolley terminal connected to the rail. The trolley-feeder circuit thus constitutes an auxiliary transmission line.

The Locomotives

Each road locomotive, of which there are ten, consists of three motive power units. All units are identical electrically and essentially so mechanically. A control stand is provided in one end of each unit. As has been explained in other articles, these locomotives are of the split-phase type, three-phase traction motors, which receive power from the single trolley wire through the main transformer and a phase converter, are used for driving the locomotives. These motors are arranged for two approximately constant running speeds of 14 and 28 miles per hour.

The mechanical parts of these locomotives were designed with the idea of keeping the structure so rigid in all directions as to enable it to withstand any and all usual service and maintenance conditions. A continuous casting, upon which is mounted most of the heavy equipment in the cab, ties the locomotive frames together for the full length between the motors. This method of supporting the heavy electrical equipment reduces to a minimum any tendency toward weaving between frames and also adds a large amount of stiffness in a vertical plane.

The locomotive units have a 16 ft. 6 in. rigid wheel



Profile and Map of Virginian Railway, Showing Electrified Zone

base and a Mikado or 1-D-1 wheel arrangement. The guiding truck, while it follows well developed principles of design, is unusual in one respect; namely, that two restraint elements are used. These elements, the swing link and the cam rocker, are so arranged that the lateral guiding force increases proportionally to the swing up to a limiting value and beyond this swing the truck functions as a constant resistance one. The main advantage of this arrangement lies in the fact that the trailing truck, with its reduced swing, imposes a less severe duty upon the leading driver flange than would be the case with a constant resistance truck.

Operation of the Electrified Zone

Every effort was made to have the beginning of electric operation cause the least possible trouble and interference with the normal operation of the railroad. A carefully studied program of instruction and training was adopted. A group of men from the railway was first sent to the plant of the Westinghouse Electric and Manufacturing Company at East Pittsburgh, where the locomotives were built. These men spent several months with the Westinghouse engineers studying the construction and operation of the locomotives. Prior to regular operation, a section of track was set aside at Princeton, W. Va. for instruction purposes. A box car was fitted up with benches, blackboards, etc., and when the first locomotive arrived in July, 1925, actual instruction of enginemen began.

Electrical operation of trains on Clark's Gap Hill began September 15, 1925, and after that instruction work was transferred to Mullens. Methods of instruction were similar, except that the added advantage of observing the operation of tonnage trains was possible. The instruction of enginemen does not stop with their completion of the prescribed course. The road foreman of engines is constantly on the road instructing enginemen in the handling of trains. The Virginian handles trains of larger tonnage than found on any other road and consequently much judgment and care must be exercised by the operators, especially at several places on the profile. A small variation in the manipulation of the controller has a pronounced effect on the smoothness of operation at certain points.

Most of the coal handled by the Virginian comes from mines west of Mullens on the main line and on the Winding Gulf Branch. This coal is brought into Elmore Yard by steam locomotives, and there trains of 6000 gross tons are made up. These 6000-ton trains are taken up the two per cent grade to Clark's Gap by a three-cab road locomotive at the head of the train and a similar locomotive acting as a pusher. The speed is 14 miles per hour and the time required to ascend the grade is 58 minutes.

Sufficient tracks are available at Clark's Gap to provide for filling out trains to 9000 tons at that point. A road locomotive takes the train east from Clark's Gap. Operation as far as Princeton was begun in September 1925, and has continued while the trolley line and substations have been in process of erection between Princeton and Roanoke. Now that this work is completed 9000-ton trains are hauled by one locomotive on the way from Clark's Gap to Roanoke.

Locomotives of the Virginian type are inherently regenerative, and trains are held on down grade without the use of air brakes. In descending from Clark's Gap to Rock, there is a small amount of regeneration. The heaviest grade to be descended by eastbound traffic is the Kellysville Hill, the top of which is just east of Princeton. This grade is approximately eleven miles long and averages 1.26 per cent, compensated east bound. The descent of this hill under steam operation has always been a problem in air braking, although the safety with which it has been accomplished is a tribute to the development of the air brake and to Virginian operating efficiency. The electric locomotives, being equipped with induction motors, are automatically regenerative. Trains now descend Kellysville Hill without the use of air brakes, the speed being held slightly above the motoring speed by the traction motors acting as generators and returning power to the distribution system. Kellysville Hill is no longer a problem.

The problem of effectively taking a tonnage train down this grade was a factor in deciding on the alternating current system of electrification, employing the split-phase locomotive. This type of locomotive is very positive in its regenerative action and this feature had considerable weight in selecting the system of electrification.

Power is, of course, returned to the line during regeneration and this power can be utilized by other trains which may be drawing power at the time. A considerable saving in energy required by the electrification is effected in this way. Power saving is, however, not the most desired adjunct to regeneration. The wear and tear on brake shoes and brake rigging was severe in the long applications of brakes which were required in going down Kellysville Hill. Air brake maintenance on this account was by no means a small item of expense, and its reduction due to regeneration constitutes a saving effected by electrification.

The foot of the grade is at Kellysville and the heavy regenerative load ends at this point. The time required to descend is approximately 44 minutes. From Kellysville to Rich Creek the average grade is still descending but the load is light. At Rich Creek the train starts on a long up grade to Whitethorne, approximately 33 miles, averaging less than 0.2 per cent. In this section, and in the section between Fagg and Roanoke, the train is operated at 28 miles per hour. The descent of Merrimac Mountain is about the same as regards regeneration as Kellysville, but the distance is less.

West bound movement on the Virginian is almost entirely of empties. The normal train, corresponding to equalized movement, weighs 2800 tons. The handling of this weight train presents no difficulties to a three-unit road locomotive.

New Drop Frame Car for General Electric

The first of a new type of drop-frame car has been tested by the General Electric Company for use in shipping large apparatus. The new car differs from the usual type of drop-frame car by the fact that the entire body or platform is made up of one steel casting.

The new car is built especially for the purpose of increasing the loading distance between the rail and clearance limitations, and, because of its peculiar type of construction, unusual strains and stresses are encountered. Former drop-frame cars have been made of structural steel but, as such types of cars are believed to be inadequate to meet the growing demand for cars to carry heavier and concentrated loads.

The car was designed by the General Electric Company and assembled by the American Locomotive Company, using a casting made by the Commonwealth Steel Company of St. Louis. It is designed to carry a concentrated load of 75 tons. The loading platform is but 22 inches above the rails, and is designed to withstand a buffing strain of one million pounds. The casting is the largest ever made by the Commonwealth Steel Company. The car is 36 feet 4 inches long, weighs 67,100 pounds and is designed to take a 150-foot radius curve.

Bright Colors Adopted for Southern Locomotives

Much attention has been attracted by the brightly painted locomotives which the Southern Railway System is putting in service to pull its fast through passenger trains. Displacing the sombre black which has been the universal garb for locomotives on American railways in recent years, the Southern has adopted a color scheme of Virginia green and gold for its passenger engines and twenty-three of the heavy Pacific type are now coming from the Richmond plant of the American Locomotive Company, dressed in the new colors. They are a part of an order for 113 locomotives which was given by the Southern in March.

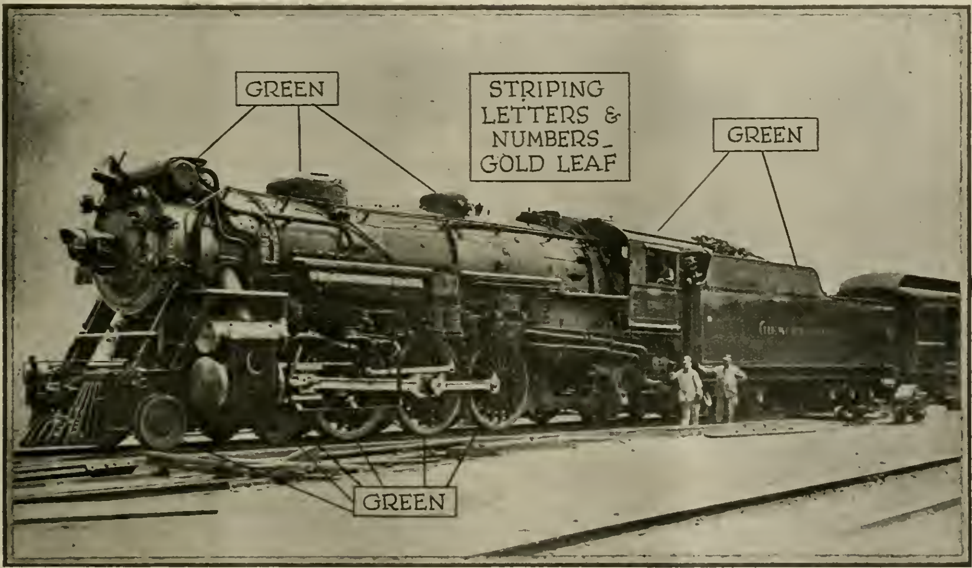
The new engines have tenders, cabs, and other projections above the boiler jackets; drivers and truck wheels painted a rich Virginia green with gold leaf striping. The boiler jackets, driving rods and other running parts are highly polished, adding greatly to the attractive appearance of the locomotives. The photograph shows No. 1393, the first of the new engines to reach Atlanta, ready to pull No. 38, the "Crescent Limited," from Atlanta to Spencer, N. C.

Four of the engines which will handle Nos. 37 and 38 between Atlanta and Washington have their tenders lettered "Crescent Limited" and three to run between Chattanooga, Birmingham and Meridian have their tenders lettered "Queen and Crescent Limited."

A distinctive feature of these new locomotives is the size of the tenders which have capacity for 14,000 gallons of water and 16 tons of coal. The tenders have twelve wheels, being mounted on two six-wheel trucks, and were designed to eliminate stops for water. They run through between Atlanta and Greenville without stopping for either coal or water. Likewise no coal or water is taken between Greenville and Spencer, N. C., where engines are changed. The engine put on at Spencer runs to Monroe, Va., without taking on coal or water, and then runs to Washington, D. C. Two engines thus make the run of 637 miles between Atlanta and Washington, each of them stopping only once for coal and water.

Like other heavy Pacific type engines now in service on the Southern, the new engines have 73-inch driving wheels, cylinders of 27-inch diameter and 28-inch stroke, and such modern improvements as mechanical stokers, power reverse gears, feed water heaters, superheaters, and brick arches. The engines alone weigh 340,000 pounds and the tenders when loaded 256,000 pounds.

In the photograph, Fireman W. A. Latimer is shown sitting in the cab, Charles A. Binney of Raleigh, N. C., service engineer for the Standard Stoker Co., and Engineer R. H. Tedder, one of the veteran men of the Southern's Charlotte division, are shown standing.



One of the New Brightly Painted Locomotives on the Southern Railway

Standard Stoker Engine Placed on the Tender

In 1924 the Northern Pacific Railway uncovered what is probably the greatest lignite coal deposit in the United States, if not in the world. Believing that this fuel could be burned to advantage and economically as compared with other fuels (oil,—subbituminous and bituminous coal) then in use, the Northern Pacific began making some experiments the results of which were so satisfactory, that they immediately began making preparations to use this fuel on an extensive scale. Owing to its comparatively low b.t.u. value however it was found advisable to equip all road locomotives with mechanical stokers.

Among other locomotives to be equipped were a number of the Pacific type, on which the actual load carried by the trailer axle was already practically up to the permissible limit of 64,500 lbs. which made it necessary to reduce the weight of the part of the mechanical stoker carried on the locomotive to the lowest possible minimum.

Inasmuch as the duPont Simplex type B stoker consists of two separate units, viz., the stoker driving engine and the conveying system, and as the units are not in-

tegral, thus permitting an optional location of the stoker engine with reference to the conveying mechanism, the mechanical engineer of the Northern Pacific suggested transferring the stoker drive engine to the left front corner of the tender. In collaboration with the Standard Stoker Company, Inc., the road worked out an application which was tried in service.

Comparing the standard application having the stoker engine located on the rear of the locomotive with the application illustrated, showing the stoker engine located on the tender, it will be seen that the transfer of the stoker engine not only solved the weight problem but further simplified the stoker in that it eliminated the universal drive shaft between the locomotive and tender, which consisted of two universal joints and the driving and driven telescoping members. The total reduction in weight carried on the locomotive is the weight of the stoker engine and its supporting bracket, the reversing valve and piping, the stoker exhaust pipe leading from the stoker engine to the front end, and approximately one-half the weight of the universal drive shaft. Aside from the stoker engine, which weighs complete 1,320 lbs., the other weights are variable, depending on the type of locomotive size of supporting bracket, length of exhaust pipe, etc. Generally speaking, the total weight removed from the locomotive is said to be approximately 1,974 lbs.

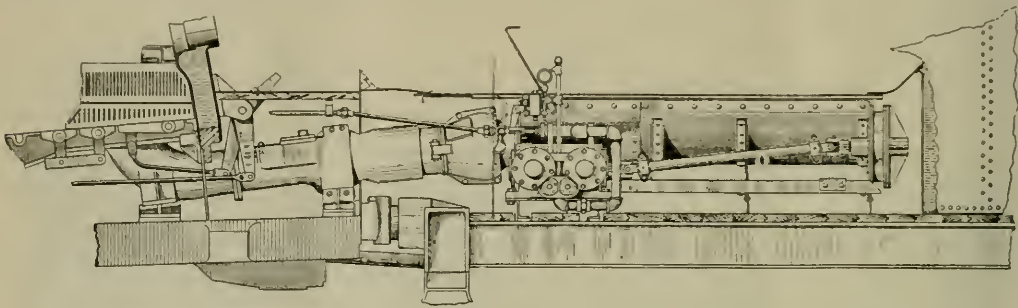
In transferring the stoker engine to the tender the supporting bracket, is eliminated as the stoker engine is supported on angle irons attached to the tender frame sill. Thus, the weight added to the tender equals the weight of the stoker engine, the reversing valve and piping, the short section of stoker exhaust pipe, and the two supporting angle irons, or a total of approximately 1,335 lbs.

In the ordinary water bottom type of rectangular tender cistern approximately 165 gallons or 1,375 lb. of water is displaced by the stoker engine, thereby leaving a perfectly balanced condition on the front tender truck.

The exhaust steam from the stoker engine is discharged into the cistern. The discharge end of the pipe is about two-thirds of the way down so as to avoid heating the water when it becomes low, beyond the lifting capacity of the injector. While the temperature of the feed water is raised by the heat in the exhaust steam, usually about 13 deg., at no time is the temperature increased to such a point that the injector will not handle it.

The weight of the steam discharged into the tender varies with the amount of coal delivered and is equal to 166 lbs. for 2,800 lbs. of coal, to a maximum of 370 lbs. when delivering 16,000 lbs. of coal. Thus, the stoker engine returns to the tender in the form of exhaust steam, from 20 to 40 gallons of water per hour, restoring the water sacrificed in making room for the stoker engine.

The stoker engine is lubricated from a tap in the main lubricator in the cab just the same as with the standard application. No difficulty has been experienced in obtaining perfect lubrication. When the stoker engine is at rest any condensation that may be obtained in the stoker engine steam pipe, which consists of a flexible pipe having three universal points, is taken care of by means of an automatic drain cock located at the lowest point of the piping system. Similar provision is made to take care of the condensation that may occur in the stoker engine exhaust pipe. Any possible syphoning action in the exhaust pipe is taken care of by a suitable vent.



Standard Stoker Driving Engine Located on Locomotive Tender

While an auxiliary lubricator is shown in the illustration this was applied only during the first application, but has since been found to be unnecessary.

The stoker engine in this location is more accessible than when located under the locomotive deck. It also leaves that part of the deck, usually occupied by the stoker drive mechanism, free for the application of any other auxiliary devices, such as shaker rigging, train control, etc.

Striking Growth of Argentine Railroads

The remarkable progress in railroad development in the Argentine Republic is shown in a monograph made public by the Commerce Department. Beginning with a six-mile line built in 1857 with equipment originally designed for use in the Crimean War, Argentine railroads have grown steadily until in 1924 they had formed a complete network about the Republic with a total mileage of almost 24,000. The development of these railroads, the report states, has been the largest single factor in the progress of the country and the history of the lines is the history of the commercial life of Argentina.

The country now has 24 railroad lines, ten of which are owned by British interests. The mileage of these British roads is more than half that of the total for the whole country. The largest of these lines—the Southern—taps one of the richest and most important sections of the country, its branches touching all the important ports of the Republic. This line carries annually about 40 million passengers and more than 5½ million tons of freight.

Coal is the largest item of consumption on the Argentina railroads. Because of the distance from the source of supply, most of Argentina's coal being imported from Great Britain, the fuel bill is one of the chief items of operating expense. During the war when coal shipments were greatly curtailed the railroads suffered severely.

According to the monograph, the large British railroads in Argentina have of late years been experimenting with oil-burning locomotives.

Railway General Foremen's Convention

The International Railway General Foremen's Association held its twenty-first annual convention at the Hotel Sherman, Chicago, on September 7 to 10 inclusive and it was the most successful meeting in the history of the organization. The membership includes mechanical supervisors in almost all branches of the mechanical department.

The convention was called to order on Tuesday, September 7, by order of H. E. Warner, president. The first speaker was E. L. Woodward, western editor of Railway Mechanical Engineer, on the Possibilities of the General Foremen's Association. Mr. Woodward emphasized the necessity of stabilizing employment and the improvement over the present system of daily wage payment in order to increase shop efficiency, and the necessity of more accurate cost data in locomotive and car shops. The afternoon session was devoted to topic of Balancing Shop Departments. The Locomotive Department was presented in committee reports by F. F. McCarthy, chairman, and the Car Department by Chairman A. H. Keys.

Wednesday's program included an address by L. C. Dickert, superintendent of motive power Central of Georgia Railway, on "The Development of the Mechanic." Mr. Dickert discussed in some detail the relative merits of the systen used on many roads today to train mechanics, and in pointing out that the railroad man of the future must have a liberal education in the practical side of railroad work. The same subject was treated by R. J. Farrington. The afternoon session was devoted to topic of Maintenance of Refrigerator Cars report and was presented by J. N. Chapman, chairman, and C. F. Bauman on the Maintenance and Preparation of a Refrigerator Car.

Thursday's program included an address by D. C. Curtis, chief purchasing officer of the Chicago, Milwaukee & St. Paul Railway, and the report of the committee on "The General Foremen's Responsibility for Material Surplus Shortage" by F. M. O'Hearn, chairman. The Afternoon session the subject of Developing Railway Shop Foremen was presented in an address by F. H. Becherer, assistant to mechanical superintendent of the Boston & Maine Railway, and by J. R. Leverage, chairman of the committee on this subject.

The last session of the convention included the installation of the new president, C. A. Barnes, general foreman, Belt Railway of Chicago, and William Hall to succeed himself as secretary and treasurer. An address prepared by H. A. Hall, superintendent of machinery, Kansas City Southern Railway, and read by C. Y. Thomas, supervisor of apprentices on the same road, "Modern Shop Equipment as a Factor in Increased Shop Production." The same subject was treated in a committee report presented by H. W. Harter, chairman.

An abstract from the address of D. C. Curtis, chief purchasing officer of the Chicago Milwaukee & St. Paul Railway, follows:

General Foreman's Responsibility for Material Shortage or Surplus

The shortage of material affects not alone the output of the shop, but also the cost of the work and is responsible for a very undesirable frame of mind on the part of the employes using material. Shortage of material should be avoided at some considerable cost if necessary.

The surplus of material affects directly only the pocket book or treasury of the railroad. However, with the railroads having difficulty to earn a fair return on their investment, a surplus of material may cost sufficient amount of money so that retrenchment in both labor and material are necessary, and in the end, the result is as bad and sometimes worse than a shortage of material or supplies.

The amount of material to be carried in store stock does not necessarily affect shortages, as proper ordering and delivery as needed avoids shortages, but the amount of material on hand always determines whether there is a surplus.

There are three factors in solving this problem that I would like to present to you: 1—Knowledge or understanding of the Fundamentals of stock control; 2—Knowledge of values. 3—Fixed program.

In the old days when a locomotive and a car were comparatively simple pieces of machinery and equipment, when signals were scarcely known, when the entire shop operation for the entire railroad could be controlled by one man, shortages, surplus and stock balances were unknown factors. Today, with the railroad purchasing a billion and a half dollars' worth of material and supplies per year, with each railroad carrying a minimum of 50,000 different items of material, with the operations spread over thousands of miles of territory, the problem becomes very complex, and to be properly solved requires a highly organized department for the procurement, distribution and care of the necessary material to prevent shortages and surplus, and to maintain a proper balance in materials account. It requires a trained store department organization, properly maintained stock books, efficient purchasing methods, and the coöperation of the supervisors of all departments.

The stock man that looks after the ordering of the material for your particular shop controls as big a business as any merchant in your town. Check his stock balances for the amount of money on the shelves under his control, and his issues in dollars and cents, and compare it with the merchant's stocks and issues in your town. He has thousands of items that he must count once each month to show the quantity on hand, the quantity he has due, the quantity he is holding orders for, and obtain information he is able to get from you as to your probable requirements, not for tomorrow, not for today, but for sixty to ninety days from today. It requires as long to make a good stockman as it does a foreman in the shop. A stockman must have not only a knowledge of the uses of material, but also a knowledge of all the factors required in procuring the numberless kinds of material.

Think of the space required for 50,000 items. If each item only took up a bin twenty-four inches wide, you would have twenty miles of bins.

The all important factor causing shortages and surplus is that we do not organize to look sufficiently in the future and so plan the work that material deliveries can be arranged to carry our plan to a conclusion.

Commercial organizations successfully make a scientific study of what the actual consumer is going to demand, and if we are going to control shortages and surplus, we must avoid the shifting desires and plans which no one can gauge accurately or economically anticipate.

If you are to be a help in the material problem, you must get a knowledge of all the detail that is necessary for your stockman to have, of the time it takes them to check their stock, make their orders, the purchasing department to ask for bids, the manufacturer's time to manufacture the goods, and sufficient time for the movement to its destination. The manufacturer today depends upon efficient railroad transportation and, consequently, does not carry any surplus stock on hand, so that he saves the interest, depreciation and other factors which mean a debit or credit on his balance sheet. You should be familiar with the arrangement of stock, and if shortages

and surplus are to be avoided, it is always desirable to carry material only in one place, so that at all times the stockman, the storekeeper and yourself may see the actual conditions. It is very necessary that material be not drawn from the store stock until actually ready for application, so that a correct knowledge may be had of the rate of consumption to enable the stockman to protect with orders on the purchasing department to replenish material as needed. It is too often that we find material in lockers, on the floor of shops and in out-of-the-way places where it is entirely lost control of by the storekeeper; this produces abnormal issues, causing both surplus and shortages. For instance, a man will draw for storage in shop a sixty days' stock of material, the storekeeper immediately replaces the amount drawn, this based on the amount of material supposedly used, then the new lot is surplus and does not move for 120 days. The next basis for ordering shows no material used in 120 days, consequently none is ordered and this produces a shortage at a later date. Standards and specifications should be worked out for all material requirements possible. The fewer the items to maintain, the easier it is to control stock. Specifications and proper description of material are needed and you can help very materially to provide them.

An ordering and delivery system should be put into effect by each one of you foremen, whereby only the actual number of pieces required be delivered, whether it be a washer, one cotter key, a nut, a bolt, or an entire side frame for a locomotive. A delivery system, preferably under the store department, should be in effect in all shops so that material will be delivered only as needed, and be placed where it is needed. By having a delivery system, it gives you supervision of the material requirements as they occur. The delivery man is interested in the material required, and also in obtaining it, and any shortage, surplus or abuse are immediately brought to your attention for correction. A delivery system is much more economical than the practice of the user obtaining his own material, as it enables the mechanic and workman to apply their entire time to output, and reduces the number of men required for the same shop output. In studies made, there have been some surprising savings made by installing a delivery system, and it is well worth considerable time and effort on your part to see that it is properly organized and efficiently carried out.

By having only exact number of pieces of material ordered that are going to be required compels the proper handling and safeguarding of each piece of material by the workman. Severe discipline should be administered to workmen for drawing any excess of material in advance of the time it is required, and this is one method of preventing both shortages and surplus.

A very simple place for the general foreman to watch, and one which is neglected, is the scrap pile. The best reclamation known is to use material to destruction at point of origin. Scrap material should be classified under the A.R.A. classification of material as it leaves the shop. I have been told that the foreman has not time to supervise the classification of scrap. The foreman and the workmen in the shop are competent to know whether cast iron, cast steel, wrought iron, chrome vanadium steel, brass, bronze and the other various kinds of material should be used for each piece of the equipment that they are repairing and handling in their shop. If they know this, they certainly, with very little study and very little effort and very little time, can direct the classification of the scrap so that it gives them first hand knowledge of whether material is being used properly, whether it is being used to destruction, or good material wasted through poor workmanship, careless methods or otherwise. Scrap properly classified brings at least $2 and more a ton when sold, as against unclassified scrap. This is a direct credit to your shop operation and reduces your operating costs accordingly. Scrap sales on a large railroad amount to $200,000 a month.

A very thorough study of the values of material should be made by each one of you, and instructions in values given to each subordinate. It is human nature to be careful with money, so every opportunity should be taken to instill in the minds of every user that every piece of material is dollars that must come out of the treasury.

A fixed program is necessary to prevent shortages and surplus of material. This is not a difficult problem to work out. All commercial firms work the problem on an actual basis, and there is no reason why a railroad in its programs for its various shops, cannot work out a fixed program that is workable. The yearly or annual program or forecast should be carefully worked out for the entire operation of each of your shops, a more detailed program should be worked out for the quarterly activities of your shop, and this broken up into monthly and weekly programs that can be followed. These programs can be so arranged and planned that they are accurate and workable.

This enables you to give the stockman the necessary information as to the kinds of material, and a close estimate of the quantities required for all the operations in your shop program in sufficient time to order the exact quantity, obtain the most economical prices, and arrange for delivery at the time required. It enables your railroad to put into effect a budget program of the amount of money that you will spend for materials and labor ahead of the time it is spent. If you are to save money, you must save it before it is spent. A budget program in dollars and cents for material may sound very difficult to put into effect. However, it is in effect and can be worked successfully with proper coöperation of all concerned. If you had a million dollars to transfer from one bank to another, you would see that the operation was consummated so that you would not lose even twenty-four hours' interest on your million dollars. Yet a railroad will order material amounting to a million dollars or more that may stay inoperative for days, sometimes weeks, and maybe months, on what is lost not only interest, but depreciation, obsolescence, taxes, handling charges and housing charges, the amount of which no one knows.

To prevent shortages, surplus, and to have a proper stock balance, requires a well organized purchasing and stores department. Many of the railroads, particularly since the days of government control, have realized this. These departments have given delivery of material so that shortages have been reduced to a minimum, have prevented surplus and reduced stock balances, with the consequent savings that have materially helped you gentlemen and the other departments make the fine showing in operating costs of our railroads.

The point I am making is that you should have a full appreciation of the part material takes in your operation, and the necessity for an efficient materials department.

This is one of the most important subjects that the railroads are solving. In order to solve it, it is necessary for you to get a thorough understanding of all the factors involved. After getting a thorough understanding, it is then necessary for you to coöperate to the fullest extent with your stores organization, and I am sure after you have taken the necessary time to get this information, you will find that with this coöperation, this understanding of values, this fixed program, that your shortages will disappear, that your road will not be burdened with surplus, and that your stock report will be a credit and a joy to your bankers.

Notes on Domestic Railroads

Locomotives

The Gulf, Mobile & Northern Railroad has ordered 2 Decapod type locomotives from the Baldwin Locomotive Works.

The St. Paul & Bridge Terminal has ordered one eight-wheel switching type locomotive from the Baldwin Locomotive Works.

The Richmond Fredericksburg & Potomac Railroad is now inquiring for 4 Pacific type and 2 six-wheel switching locomotives.

The Norfolk & Western Railway has ordered 10 heavy Mallet type locomotives from the American Locomotive Company.

The New York Central has ordered 20 heavy freight 2-8-2 type locomotives from the Lima Locomotive Works; has also placed an order for 25 Pacific type heavy passenger locomotives with the American Locomotive Company.

The Minneapolis, St. Paul & Sault Ste Marie Railway has ordered 10 Mountain type locomotives from the American Locomotive Company. These locomotives will have a total weight in working order of 336,000 lbs.

The Kaiyuan Hailungsheng Railway, at Taolu, will purchase 3 locomotives.

The Kentucky & Indiana Terminal Railroad has ordered 6 eight-wheel switching locomotives from the Lima Locomotive Works.

The Boston & Albany Railroad has ordered 20 freight locomotives of the Berkshire type from the Lima Locomotive Works and 5 from the American Locomotive Company.

The Chicago, St. Paul, Minneapolis & Omaha Railway will probably be in the market for 8 locomotives in the near future.

The Scrocabana Railway of Sao Paula, Brazil, has plans for the purchase of 50 electric locomotives.

The Carnegie Steel Company has ordered one 80-ton electric locomotive from the Westinghouse Electric & Manufacturing Co.

Passenger Cars

The Chicago & North Western Railroad is inquiring for 4 dining cars.

The Manila Railroad contemplates buying 12 passenger cars.

The Boston & Albany Railroad has ordered 2 parlor observation cars from the Pullman Car & Manufacturing Corporation.

The Chicago & Alton Railroad has ordered 2 eight-wheel highway motor coaches from the Versare Corporation.

The Erie Railroad has ordered 26 steel passenger car frames from the Pressed Steel Car Company.

The Chicago & North Western is inquiring for 2 baggage-dormitory cars.

The Kaiyuan-Hailungcheng Railway, at Taolu, will purchase 20 passenger cars.

The Southern Pacific Company has ordered 11 dining cars from the Pullman Car & Manufacturing Corporation.

The Gulf, Mobile & Northern Railroad is inquiring for 2 steel underframes for passenger cars.

The Union Pacific Railroad is inquiring for 7 70-foot combination baggage-sleeping cars.

The Chicago & Northwestern Railway is inquiring for 2 70-foot combination baggage-sleeping cars.

The Erie Railroad has ordered 15 additional steel passenger coaches from the Standard Steel Car Company.

The Canadian National Railway is reported to have placed an order for 30 coaches with the Canadian Car & Foundry Company.

The Richmond, Fredericksburg & Potomac Railroad has purchased one dining car from the Pullman Car & Manufacturing Corporation.

Freight Cars

The United States Cast Iron Pipe Company is inquiring for 10 50-ton gondola cars.

The Palace Poultry Car Company is inquiring for 200 all steel live poultry cars.

The Chicago North Shore & Milwaukee Railroad is inquiring for 4 caboose cars.

The Missouri Pacific Railroad is in the market for 2,000 box cars.

The Pittsburgh Crucible Steel Company has ordered 5 flat cars from the Standard Steel Car Company.

The Atlantic Coast Line Railroad has ordered 50 steel underframes from the Virginia Bridge & Iron Company.

The Public Belt Railway of New Orleans is inquiring for 50 box cars.

The Chicago Great Western Railroad has ordered 300 box cars and 100 automobile cars from Pullman Car & Manufacturing Corporation.

The Westinghouse Air Brake & Manufacturing Company is inquiring for 5 dump cars.

The Fruit Growers Express has ordered 533 steel under-frames from the Pressed Steel Car Company.

The East Jersey Railroad & Terminal Company has placed an order for 11 steel under-frames with the American Car & Foundry Company.

The Pennsylvania Railroad has contracted with the Ralston Car Company for repairs to 200 cars.

The Sinclair Refining Company is inquiring for 16 special type coke cars.

The Louisville & Nashville Railway will build 50 cabooses at its Louisville shops.

The Inland Waterways Corporation, operating the Warrior River Terminal Company, has placed orders for 40 gondola cars with the Tennessee Coal, Iron & Railroad Company.

The Interstate Oil Shippers Line, Chicago, Ill., is inquiring for 40 tank cars.

The Illinois Traction Company is inquiring for 100 50-ton gondola cars.

The Shippers Car Line is inquiring for 300 tank cars of 8,000 gallons capacity and 200 tank cars of 10,000 gallons capacity.

Cheswick & Harmer, Philadelphia, is inquiring for 10 steel hopper cars of 55 tons capacity.

Buildings and Structures

The Canadian National Railways and the Wabash Railway plan new yards at Niagara Falls, to cost approximately $500,000.

The Atlantic Coast Line Railroad has placed a contract for the construction of a coaling station at St. Petersburg, Fla., of concrete and steel which will cost approximately $31,500.

The Baltimore & Ohio Railroad has awarded a contract for freight yards, track, and an engine-house at Youngstown, Ohio, to cost approximately $750,000.

The Atchison, Topeka & Santa Fe Railway contemplates the construction of a frog and wheel shop at Emporia, Kan.

The New York, New Haven & Hartford Railroad will proceed with the construction of its proposed new machine repair shop at East Hartford, Conn. It is to replace the structure destroyed by fire several months ago.

The Texas & Pacific Railway has planned the construction of a concrete and steel valve-motion shop at Marshall, Texas, to cost approximately $11,000.

The Pennsylvania Railroad has asked for bids on a one-story shop at its Altoona shops, to be used for tank car repair and service work. A crane runway is to be installed.

The Chicago, Burlington & Quincy Railroad is planning the construction of a one-story locomotive repair shop at Bridgeport, Neb., to cost approximately $35,000 with equipment.

The Lehigh Valley Railroad has plans for a one-story addition to its local repair shops at Weatherly, Pa., to cost $45,000 with equipment.

The Chicago, St. Paul, Minneapolis & Omaha Railway has plans for a one-story engine-house with shop facilities at Sioux City, Iowa, to cost approximately $35,000.

The Baltimore & Ohio Railroad is preparing plans for enlargement of its yards and terminal facilities, including shops at Toledo, at an estimated cost of $1,500,000.

The International Great Northern Railway has plans for extensions to its locomotive repair shops at Palestine, Texas, consisting of enlargement of the engine-house, machine shop, and other building to cost, including equipment, $85,000.

The Union Pacific Railroad is spending over $200,000 in waterworks improvements at Rock Spring, Wyoming.

The New York, New Haven & Hartford Railroad has awarded contracts for the erection of engine-house and machine shops at New Bedford, Scituate, and Fall River, Mass.

The Maine Central Railroad has started the construction of an engine-house, machine shop and storage plant at Lewiston, Maine.

The Chicago & Eastern Illinois Railway contemplates car repair yards and a blacksmith shop at Evansville, Ind., to cost approximately $75,000.

The Southern Pacific Company has plans prepared for the construction of a brick and reinforced concrete engine-house at Dallas, Texas, to cost approximately $55,000.

The Wabash Railway has awarded a general contract for the erection of a car repair shop at Detroit, to cost approximately $100,000.

The Chicago, Milwaukee & St. Paul Railway will proceed soon with the construction of a new steam-operated electric power plant at Channing, Mich., to cost about $55,000.

The Erie Railroad is receiving bids on a refrigeration plant at Jersey City, New Jersey.

The Seaboard Air Line Railway has placed an order with the Roberts & Schaefer Company, Chicago, for the construction of another 200 ton capacity reinforced concrete automatic electric, Simplex roller skip type coaling station with sanding facilities for immediate installation at Indiantown, Fla.

The Central Railroad of New Jersey has under way the construction of a large terminal at Bethlehem, Pa., about a mile east of its Allentown freight classification yards. The group of buildings to be erected includes a car repair shop, with modern machinery for the building and repairing of equipment, an enginehouse capable of housing thirty-six of the largest type locomotives, a turntable, a large warehouse, ash-pits and coaling docks, a machine shop, etc.

The Yazoo & Mississippi Valley Railroad has awarded a contract for the construction of a water treating plant with a capacity of 30,000 gallons per hour at Baton Rouge, La., to the Joseph E. Nelson & Sons.

The Chicago & North Western Railroad has awarded a contract for the construction of a water treating plant at New Elm, Minn., to the Joseph E. Nelson & Sons.

The Southern Illinois & Kentucky Railroad has awarded a contract for the construction of a pumping plant and deep well water supply at Reevesville, Ill., at estimated cost of $45,000 to the Joseph E. Nelson & Sons.

Items of Personal Interest

Roston Tuck has been appointed acting master mechanic of the Arizona division of the Atchison, Topeka & Santa Fe Railway, with headquarters at Needles, Calif., succeeding **G. Searle.**

R. A. McCranie, general superintendent of the Atlantic Coast Line Railroad, has been promoted to assistant general manager, with headquarters at Jacksonville, Fla. **J. P. Walker,** superintendent of transportation, succeeds R. A. McCranie as general superintendent.

O. E. Ward, master mechanic of the Chicago, Burlington & Quincy Railroad, with headquarters at Alliance, Neb., has been promoted to superintendent of motive power, with headquarters at Omaha, Neb., succeeding **T. Roope.** Mr. Ward will be succeeded by **G. B. Pauley,** master mechanic, with headquarters at Omaha, Neb.

Charles D. Waring has been appointed general yardmaster, Pocatello yard of the Union Pacific Railroad to succeed **R. D. Griffin,** who has resigned.

H. W. Reinhardt has been appointed master mechanic of the Missouri Pacific Railroad, with headquarters at Little Rock, Ark.

E. R. Dowdy, recently appointed master mechanic of the Richmond division of the Chesapeake & Ohio Railway, was born in Cumberland County, Va., April 18, 1880, and received his education at Miller Manual Labor School near Crozet, Va. He served an apprenticeship with the Newport News Shipbuilding & Dry Dock Company and then entered the service of the Chesapeake & Ohio Railway in 1902, as a machinist and was in Richmond shops until 1915, when he was promoted to assistant foreman and later foreman. He was appointed assistant master mechanic at Fulton shops, Richmond, Va., in 1925 and held that position until his recent appointment as master mechanic to succeed **F. B. Moss,** deceased.

Frank Roehr, master car repairer of the San Joaquin division of the Southern Pacific Railroad, with headquarters at Bakersfield, Calif., has been transferred to the Los Angeles division, with headquarters at Los Angeles, Calif., succeeding **T. H. Osborne,** transferred. **D. D. McClure** will replace Mr. Roehr.

G. G. Ritchie has been appointed chief fuel inspector of the Chesapeake & Ohio Railway, with headquarters at Richmond, Va., succeeding **S. Hernaman,** retired.

C. E. Alderson has been appointed assistant to the superintendent of the Newport News and Norfolk Terminal subdivision of the Chesapeake & Ohio Railway, with office at Newport News, Va.

B. H. Gray, superintendent of motive power of the Gulf, Mobile & Northern Railroad, with headquarters at Mobile, Ala., has been appointed superintendent of motive power of the Jackson & Eastern Railway, with headquarters at Mobile, Ala.

H. H. Urback has been appointed assistant superintendent of motive power of the Chicago, Burlington & Quincy Railroad, with headquarters at Chicago to succeed **H. Modaff,** who has been transferred. **G. B. Pauley** has been appointed master mechanic of the Alliance division, with headquarters at Alliance, Neb., to succeed **O. E. Ward,** who has been promoted. **G. P. Trachta** has been appointed master mechanic of the Omaha division, with headquarters at Omaha, to succeed Mr. Pauley.

O. A. Garber, mechanical superintendent of the Missouri Pacific Railroad, with headquarters at St. Louis, Mo., has been promoted to assistant chief mechanical officer, with the same headquarters.

A. P. Housholder, master mechanic of the Missouri Pacific Railroad, with headquarters at St. Louis, has been promoted to mechanical superintendent of the Texas lines, with headquarters at Houston, Tex., and will be succeeded by **J. M. Whalen,** master mechanic, with headquarters at Little Rock, Ark.

G. P. Brock has been appointed assistant general manager of the Jackson & Eastern Railway, with headquarters at Laurel, Miss., and **C. E. Lanham** has been appointed superintendent of transportation, with headquarters at Mobile, Ala.

F. E. Yoakum has been appointed assistant superintendent of the Southern Pacific Company, with headquarters at Oakland, Calif., to succeed **W. H. Norton,** who has retired.

James P. Walker has been appointed general superintendent of the Atlantic Coast Line Railway, with headquarters at Savannah, Ga.

B. J. Feeny has been appointed superintendent of fuel conservation of the Illinois Central Railroad, with headquarters at Chicago, to succeed J. W. Dodge, who has retired.

John Cannon, general manager of the Missouri Pacific Railroad, with headquarters at St. Louis, Mo., has been elected vice-president and general manager in charge of operation, with same headquarters.

L. P. O. Exley has been appointed chief engineer of the Jackson & Eastern Railway, with headquarters at Laurel, Miss.

H. R. Gibson, division engineer of the Baltimore & Ohio Railroad, with headquarters at Connellsville, Pa., has been promoted to superintendent, with headquarters at Newark, Ohio.

A. E. Staub has been appointed assistant to the vice-president and general manager of the Delaware, Lackawanna & Western Railroad, with headquarters at New York, N. Y.

Supply Trade Notes

The Locomotive Firebox Company, of Chicago, has opened a New York office at 30 East Forty-second street in charge of **George N. DeGuire,** assistant to the president of the company.

L. W. Barger is now works engineer for both the **Symington Company** and the **Gould Coupler Company,** Depew, N. Y.

W. S. Jones, formerly vice-president of the **Vanadium Alloys Steel Company,** Latrobe, Pa., has been elected vice-president in charge of tool steel sales for the **Carpenter Steel Company,** Reading, Pa.

F. A. Whitten has been appointed engineer in charge of design and development for the **American Car & Foundry Motors Company.** Mr. Whitten formerly was chief engineer for **General Motors Truck Company,** having served in that capacity for over thirteen years.

V. M. Wall, formerly assistant manager of the **National Cast Iron Pipe Company** at Los Angeles, has been transferred to the Chicago office to succeed **F. J. Egan,** who has resigned.

T. E. Doremus, northwest manager for **E. I. DuPont de Nemours Company,** Wilmington, Del., has been transferred to New York.

M. C. Peterson has been appointed Chicago district sales manager of the **Sunbeam Electric Manufacturing Company,** with office in Evansville, Ind. Mr. Peterson was formerly connected with the **Baldwin Locomotive Works.**

William A. Salt, formerly with the **Crucible Steel Company of America,** has become associated with the **Jessop Steel Company,** Washington, Pa., and will be in charge of its Chicago branch.

O. R. Lane, who assisted **F. W. Deppe,** until recently in the administration of the affairs of **Reading Iron Company** in the St. Louis territory, has opened an office in Kansas City for that company at 721 Pioneer Trust building.

J. N. Joyce, formerly connected with **Johns-Manville,** with headquarters at New York, has joined the Cleveland sales force of the **Bridgeport Brass Company,** Bridgeport, Conn.

The Waugh Equipment Company, Chicago, Ill., announces that it has acquired all of the outstanding capital stock of the **Railway Improvement Company,** New York, and will amalgamate the two companies at once, operating the combined companies under the name of the **Waugh Equipment Company,** maintaining offices in New York and Chicago.

George W. Daves has resigned his position as sales representative of the **Fairmont Railway Motor Company** to become a representative of "Copperweld" with the Steel Sales Corporation in the Chicago territory.

C. C. Ousterhout has been appointed assistant manager at sales of the **Rome Iron Mills,** with offices at Rome, N. Y.

K. I. Clisby has been appointed New York representative of the **Clark Controller Company,** with headquarters at Cleveland, Ohio.

Le Monte Judson Belnap, recently elected president of the **Worthington Pump & Machinery Corporation** of New York.

E. C. Sicardi, president of the **Union Tank Car Company,**

has retired after thirty-six years of service with the company.

C. H. Van Allen has been appointed manager of the Chicago office of the **Pittsburgh Steel Products Company** to succeed **C. F. Palmer.**

H. T. Armstrong has been appointed manager of sales of the **Montreal Locomotive Works** and the **Canadian Steel-Tire & Wheel Company,** with offices in the Dominion Express building, Montreal.

The Chicago Railway Signal & Supply Company has removed its New York office from 30 Church street to 114 Liberty street.

C. C. Osterhout, chemist and enginerr of tests of the **Rome Iron Mills, Inc.,** has been appointed assistant manager of sales, with headquarters at Rome, N. Y.

The Oakley Chemical Company, New York City, has changed its name to **Oakite Products, Inc.**

The executive and general offices of the **Union Tank Car Company** will be moved from New York City to 134 North LaSalle street, Chicago, Ill.

The North American Car Corporation, Chicago, has acquired control of the **Palace Poultry Car Company,** Chicago. Officers of the new company are Erwin R. Brigham, president; I. V. Edgerton, vice-president, and N. M. Stott, secretary-treasurer.

R. F. Stubbleine, railway sales engineer of the **Hale Kilburn Company,** has been appointed eastern sales manager, with headquarters at 30 Church street, New York, succeeding **A. F. Old,** deceased.

George B. Fowell has been appointed sales agent of the **Railway Steel Spring Company,** with headquarters at the Syndicate Trust building, St. Louis, Mo., succeeding **George M. Burns,** deceased.

B. M. Cheney, president of **Laughlin & Cheney, Inc.,** Chicago, Ill., sales agent for the **Verona Tool Works** and other companies, has been appointed sales manager of the Verona Tool Works, with headquarters at Chicago, and the firm of Laughlin & Cheney, Inc., has been dissolved.

G. J. Meyer, representative of the **Truscon Steel Company** at New England, has been transferred to the company's Youngstown plant to take charge of new work. **L. A. Estes** is now in charge of the Boston office.

The business of the **Leslie Company of Lyndhurst,** N. J., manufacturers of Leslie pressure regulators and reducing valves, has been purchased by S. Inglis Leslie and a new company has been organized to be known as the **Leslie Company,** with the following officers in charge: **S. Inglis Leslie,** president; **J. J. Cizek,** vice-president, and **J. M. Naab,** secretary and treasurer. The following have been elected directors of the new company: **William L. Allison,** senior vice-president of the **American Arch Company; F. A. Schaff,** vice-president of the **Superheater Company,** and **Frederic E. Schluter,** president of **Schluter & Company,** investment bankers.

The Roberts Tool & Supply Company, Syracuse, N. Y., has been appointed district representative for the speed reducers and gear products of the **Foote Brothers Gear & Machine Company,** Chicago, Ill.

Obituary

W. H. Fetner, chief mechanical officer of the Missouri Pacific Railroad, with headquarters at St. Louis, Mo., died at his home in that city. Mr. Fetner was born on September 1, 1867, at Columbia, S. C., and was educated in the local public schools at that point and entered railroad service in 1881 with the Illinois Central Railroad at Water Valley, Miss. He served consecutively as machinist, gang foreman and locomotive engineer with the Southern Railway at Columbia, S. C., until 1892 and then entered the employ of the Central of Georgia Railway as a gang foreman in the shops at Macon, Ga., where he remained until 1917. He served as erecting shop foreman and master mechanic at that place, and then as general master mechanic for the entire system. He was appointed superintendent of motive power for the Central of Georgia Railway, with headquarters at Savannah, Ga., and held that position up to the time he entered the service of the Missouri Pacific Railroad some three years ago. Mr. Fetner went to the Missouri Pacific as assistant to the president and a few months later was made chief mechanical officer, his jurisdiction being extended to include the Gulf Coast Line and the International Great Northern Railroad, effective April 1, 1926, in which position he served at the time of his death.

William A. Nettleton, formerly superintendent of motive power of the Chicago, Rock Island & Pacific Railway, died on August 30 during a trip abroad in London, England. Mr. Nettleton was born in October, 1863, at Hannibal, Mo., and graduated form Yale University in 1885. He entered railway service in the same year and served as rodman and levelman on the Kansas City, Ft. Scott & Memphis Railroad, now a part of the St. Louis, San Francisco. In 1886 he entered a student course with the Westinghouse Air Brake Company, and in the next year was appointed inspector of air brakes of the Kansas City, Ft. Scott & Memphis Railroad. After a short course with Union Bridge Company at New York. Mr. Nettleton was inspector for the Morrison & Corthell Union Bridge Company at Athens, Pa., and for the C. A. Boller on the Thames river-bridge at New London, Conn. He was engineer of tests of the Kansas City, Ft. Scott & Memphis until 1893. The next two years he served as assistant superintendent of motive power and then was promoted to superintendent of motive power and machinery. In 1902 he entered the service of the Atchison Topeka & Santa Fe Railway as assistant superintendent of motive power and consulting engineer until 1904, when he was made general superintendent of motive power of the St. Louis-San Francisco Railway and the Chicago & Eastern Illinois Railway. He was appointed general superintendent of motive power of the Chicago, Rock Island & Pacific Railway in 1918, which position he held until his retirement in 1921.

A. Edward Olmstead, civil engineer, prominent for his work on railroads, died at his home in East Hartford, Conn., on August 15, in his eightieth year. Mr. Olmstead was associated with the building in 1870 of the southern division of the Connecticut Valley Railroad from Saybrook to Deep River, Conn. He was also connected with the building of railroads in Pennsylvania and New York, as well as many other states. Probably his notewotrhy work was done on the New York subway, where he was division engineer until 1918.

William H. Elliot, vice-president and a director of the Ramapo Ajax Corporation and former president of the Elliot Frog & Switch Company, of East St. Louis, Ill., died on August 8 at Green Bay, Wisc., at the age of 62.

William Hood, formerly chief engineer of the Southern Pacific Company, died on August 26, at his home in San Francisco, after a short illness. Mr. Hood was born on February 4, 1846, and was graduated from Dartmouth College. He entered railway service in 1867 as rodman on the Central Pacific being promoted to assistant engineer in 1868. Mr. Hood was transferred to the Southern Pacific in 1872 and in 1875 was promoted to chief assistant engineer. He served in a similar capacity on the Central Pacific. He was made chief engineer of the Southern Pacific in 1885, holding that position for more than a third of a century until his retirement in May, 1921.

George M. Burns, sales agent of the Railway Steel Spring Company, with headquarters at St. Louis, Mo., died on August 16, at his home in St. Louis, from a paralytic stroke. Mr. Burns was born in Coshocton, Ohio, in 1858, and entered railway service in 1872 as a clerk on the Cincinnati, Hamilton & Dayton Railroad, now a part of the Baltimore & Ohio Railroad. During his railroad career, he was employed by the Cleveland, Cincinati, Chicago & St. Louis, the Southern, the Pennsylvania and the Wabash railroads. His connection with the Wabash began in 1895, when he was made chief clerk to the vice-president, being later promoted to superintendent of the Detroit division which headquarters at Detroit, where he remained until 1906, when he resigned to accept the position of sales agent of the Railway Steel Spring Company.

New Publications

Books, Bulletins, Catalogues, Etc.

Standard 250 Horsepower Gasoline-Electric Car Equipment. —The Westinghouse Electric & Manufacturing Company has issued an eight-page folder describing standard gasoline-electric equipment for rail cars. One page is devoted to a description of each of the following equipment:

The Power Plant.—A Brill 250-hp., 6-cylinder gasoline engine directly connected to a Westinghouse 600-volt d-c. generator.

Motors are standard railway equipment. The control is standard Westinghouse electro-pneumatic type for multiple-unit operation and double-end control. The scheme of operation is described briefly.

Car Data includes important dimensions and weights of the J. G. Brill light-weight type 60-foot car on which a considerable number of equipments have been installed and placed in actual service. A list of the equipment required for outfitting a car for gasoline-electric operation is given also.

Performance.—Performance data is given for the 60-foot

car operating alone on straight, level track, and with a load under similar conditions.

The folder is illustrated with a picture of the engine generator unit, a plan and elevation of a Brill-Westinghouse 60-foot gasoline-electric car and a reproduction of a Brill-Westinghouse gasoline-electric car now in the service of the Reading Company.

Copies of this folder may be obtained free of charge from any Westinghouse district office, or from the Transportation Section of the Department of Publicity of the company at East Pittsburgh, Pa., by applying for Folder 4710.

Locomotive Superheating and Feed Water Heating.—The Locomotive Publishing Company has issued a book on Locomotive Superheating and Feed Water Heating. The volume contains a wide survey of the important subjects contained in the title, commencing with a study of the theory of superheated steam, the economics of superheating, and a brief history of the superheater locomotive, passing on from this to a consideration in detail of the practical design and construction of locomotive superheating and feed water heating apparatus. It has recorded some of the best known modern developments, many of these having reached a very practical and efficient stage.

Among the pioneers in these efforts to obtain more satisfactory utilization of the heat units generated in a steam locomotive must be mentioned such prominent names as Cudworth, Beattie, McDonnell, etc., etc. Several illustrations of the arrangements adopted by these capable designers are included in the book, and form interesting records in the gradual progress of the work of improving the locomotive.

The advent of the Schmidt "fire tube" superheater, of course, represents a notable milestone in the gradual adoption of superheating; the recent rapid development is remarkable, for it is more the exception than the rule today to chronicle in our pages the construction of a new locomotive utilizing saturated steam in its cylinders.

In the feed water heating section similar attention is given to the progress of this important means of securing economy in locomotive operation. Details of early apparatus is illustrated and described, whilst many of the latest developments in Europe and America form the subject matter of careful enquiry and study.

Copies of this book may be obtained from the Locomotive Publishing Co., Ltd., 3 Amen Corner, London, E. C. 4, England. Price $1.25.

Railroad Sand Drying Equipment.—The Roberts & Schaefer Company, Chicago, Ill., has issued a bulleting which describes its various equipment for drying and handling locomotive sand, ranging from the simple stove driers to the automatic devices which eliminate practically all labor. The bulletin is well illustrated with views and plans showing the construction of the different devices. Copies of these bulletins may be obtained free of charge from the nearest office of this company.

Motor Starting Oil Circuit-Breakers Described in New Westinghouse.—Leaflet 20292 has recently been released by the Westinghouse Electric & Manufacturing Company describing the Type MF Motor Starting Oil Circuit-Breakers. Such features as the manual operation, indoor service, non-automatic starting position, and the automatic running position are pointed out, and the application, operation, construction and engineer's specifications are discussed. There are two tables, one showing the ratings for motor starting breakers, and the other listing the motor starting breakers of the type MF complete. This leaflet may be had at any of the district offices of the Westinghouse Company or at the Publicity Department at East Pittsburgh, Pa.

Commerce Year Book.—We have received notice from the Bureau of Foreign and Domestic Commerce that the Commerce Year Book, 1925, is now ready for distribution. This book, the bureau states, contains a complete and authentic record of American trade and industry during last year. It is designed to give the business man a bird's-eye view of American industrial progress, material having been gathered from every available source and analyzed by experts.

The publication contains nearly 800 pages, with numerous charts, maps and tables. Copies can be had at office of the Bureau of Foreign and Domestic Commerce in Custom House or from Superintendent of Documents, Washington, D. C., at a charge of $1.00 per volume, to cover cost of publication.

Westinghouse Catalogue on Battery Chargers.—The Westinghouse Electric & Manufacturing Company has just released a new catalogue on Rectigon Battery Chargers that is well written and is complete with descriptions of the various types of Westinghouse Battery Chargers and their applications. The catalogue is divided into sections that describe the application, operation and construction of radio and private garage rectigon outfits, home and garage outfits, radio "B" battery charging attachments, telephone rectigon outfits, the 6-ampere 75 volt rectigon outfit, and the 12 ampere 75 volt rectigon outfit.

This publication, catalogue 284, is well illustrated with halftone illustrations of the various types. It may be obtained at any of the district offices of the Westinghouse Company or from the publicity department at East Pittsburgh, Pa.

Railroad Yard Lighting.—General Electric has issued a 16-page bulletin GEA.-131 devoted entirely to descriptive information on railroad yard lighting. The group and distributed systems are discussed. Several typical plans and illuminations data on standard projecters make this bulletin a fairly complete text on the subject of railroad yard lighting. Copies may be obtained from the general offices of the company.

Railway and Locomotive Engineering

A Practical Journal of Motive Power, Rolling Stock and Appliances

Vol. XXXIX 136 Liberty Street, New York, October, 1926 No. 10

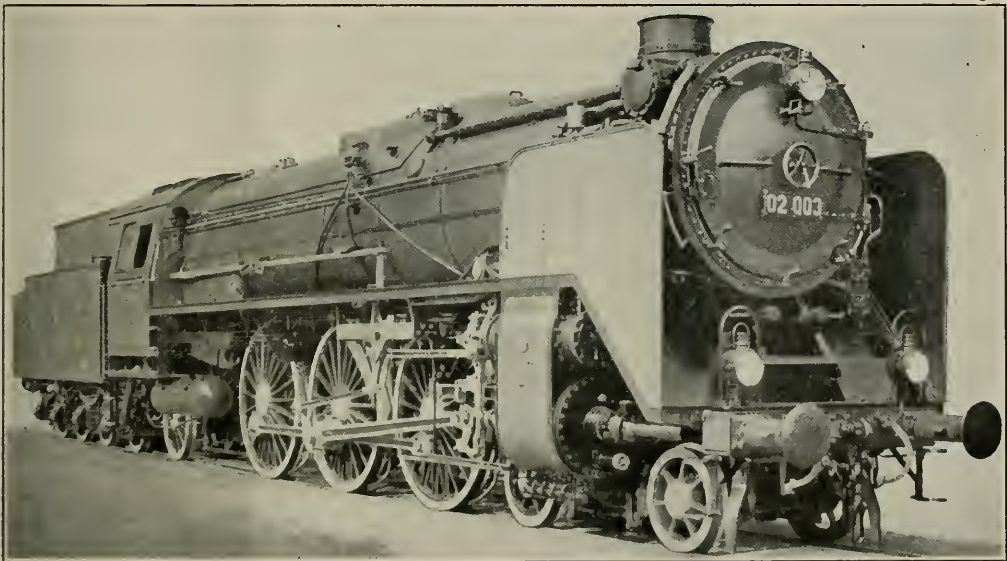
Three and Four Cylinder Locomotives of the German State Railways

High-Powered Pacific for Passenger and 2-10-0 for Freight Service

In connection with the unification of railway control in Germany, an effort is being made to standardize practice in the design of locomotives and other rolling ekuipment. For many years there has been in operation on the various State railways a multiplicity of types of locomotives and the consolidation of these roads into one system under the same management or control called for the standardization of locomotive power to replace the uneconomic conditions resulting from the former widely diversified control.

The designs for various classes and types of locomotives have been worked out in detail and some engines have been built and placed in service. Other and more advanced types are being built and will be introduced in fast passenger and heavy freight service.

One of the types referred to is a Pacific or 4-6-2 express locomotive, which for the purpose of comparison has been built in two different forms, a two-cylinder single expansion and a four-cylinder compound. Another is a heavy freight engine of the 2-10-0 wheel arrangement which was also built in two different forms, namely, two-cylinder and three-cylinder single expansions.



New Standard Four-Cylinder Compound 4-6-2 Type Locomotive for the German State Railways

Standard Pacific Type Locomotive

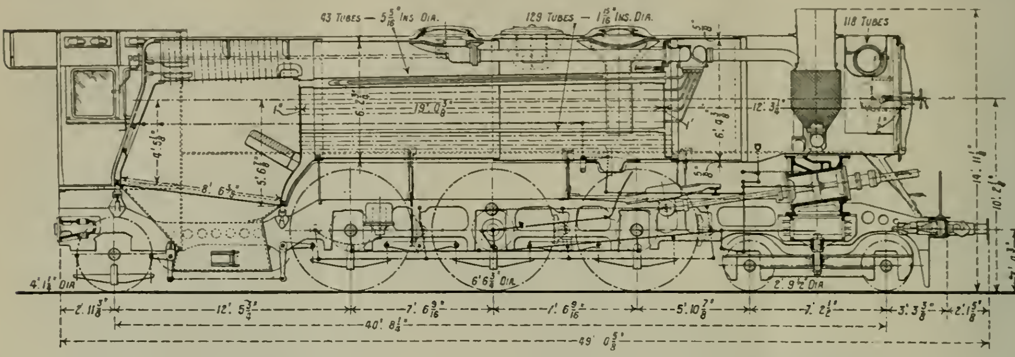
One of the most notable features of this locomotive is the fact that the axle loading is now about 40,000 lbs., as against the 35,000 lbs. hitherto used. For this reason the power output of the locomotive will be proportionately greater than others having the same wheel arrangement, and it may be pointed out that these new locomotives have been designed to handle 60 axle trains which were beyond the capabilities of the six-coupled engines previously employed in fast passenger service.

The new engines present many novel features, amongst them being bar frames which are to be uniformly employed in all the standard types in future. The frames are formed from rolled steel plates 3 15/16 in. thick, whereas the ordinary plate frames previously used for German locomotives were 31/32 to 1 3/16 in. thickness. The reasons given for the adoption of the bar type of frame are improved accessibility of the inside parts and the ease with which a wide firebox can be used, thus obtaining a large grate surface without resorting to an excessive firebox length.

In order to maintain continuous development of high power, a large boiler has been provided with a correspondingly large heating surface. The diameter 74¾ in. and the length between the tube plates is 19 ft. The boiler barrel contains tubes 5 5/16 in. diameter, arranged in five rows one over the other, for the reception of the large superheater of the Schmidt type, and 129 fire tubes 1 15/16 in. diameter. The barrel carries a steam dome and a feed-water mounting with angular grid water purifier. The smokebox extends over the cylinder saddle, and the preheater is placed transversely above it in front of the chimney, whilst the air and feed pumps are placed to left and right of the boiler barrel, in order to give the enginemen as free a view as possible. The feeding of the boiler is effected by means of an injector and a Nielebock feed pump. The valves necessary for operating the injector, the steam-heating device, coal and ash-pan spraying devices, etc., are placed in a steam connection arranged on the left-hand side of the firebox, whilst the steam necessary for operating the air and feed pumps, the whistle and the blower is taken from a steam connection placed on the left-hand side of the smoke chamber.

The center line of the boiler is 10 ft. 2½ in. above the rail level, which height is employed in order to obtain a sufficiently deep firebox. The result of this high center line is reflected in the size and shape of the domes, sandbox, chimney and other fittings, the former being, as will be seen from the illustration, of reduced height. The extension shown on the chimney is permissible only on certain sections of the road. The dome next the firebox contains the throttle or regulator valve, which is of the well-known Schmidt & Wagner type, whilst that in front of the sand-box contains the feed-water purifier working in connection with the Knorr feed-water preheater, which is fitted transversely in the smokebox immediately in front of the chimney. The feed water is heated to about 212 deg. Fahr. and upon entery into the feed-water dome it is broken up into spray-like form, when, owing to its mixing with the steam in the steam space, it is further heated to about 276 deg. Fahr., at which temperature the scale-forming particles are separated and deposited on a series of trays, from whence they are conveyed by means of rectangular ducts, formed round the inside periphery of the boiler barrel, into a sump, which can easily be blown out after each trip through a valve fitted specially for this purpose. The purifying trays are removable for cleaning. In addition, a blow-off cock is provided at the back of the boiler, and here are no fewer than 32 mud doors. The condensate from the preheater is returned to the tender tank after having first passed through an oil separator. In this manner about 15 per cent of the water evaporated in the boiler is passed back to the tank as clean, hot water, and, of course, free from scale deposits.

Contrary to ordinary practice, the various fittings for supplying steam for the injector, steam heating, feed water and air pumps are located outside the cab, and with a view to avoiding long pipe connections one steam turret is placed on the firebox in front of the cab, and another forward on the left hand side of the smokebox. The fire grate is fitted with a drop portion operated by hand by means of a wheel and screw. The ashpan is provided with the necessary dampers, as usual and in addition, with easily manipulated ash hoppers.



Four-Cylinder Compound Standard Pacific Locomotive of the German State Railways

The construction of the superheater header in the smokebox is peculiar, inasmuch as the saturated and superheated sections are separate castings bolted together. This construction has for its object the eliminating of fractures which might arise from the stresses set up by the difference in the temperature of the sections for the saturated and superheated steam. The feed-water pump and the air brake are arranged at either side of the smokebox.

The engine as seen, is fitted with wind guides, these being for the purpose of deflecting the smoke upwards when the engine is running, thus preventing it from heating down, and in the way obstructing the view from the cab.

In order to ensure the safe negotiation of curves, the leading truck is constructed on the Adams principle, allowing for lateral motion, and the trailing pair of wheels is arranged in the same manner. Further, so that the engine may run steadily on straight portions of the track, strong leaf or laminated check springs control the lateral motion of the leading truck whilst that of the trailing truck is effected by helical springs. The diameter of the coupled wheels is 6 ft. 6¾ in., which enables the locomotive to attain a speed of 74.5 miles per hour.

The center lines of the two high-pressure cylinders

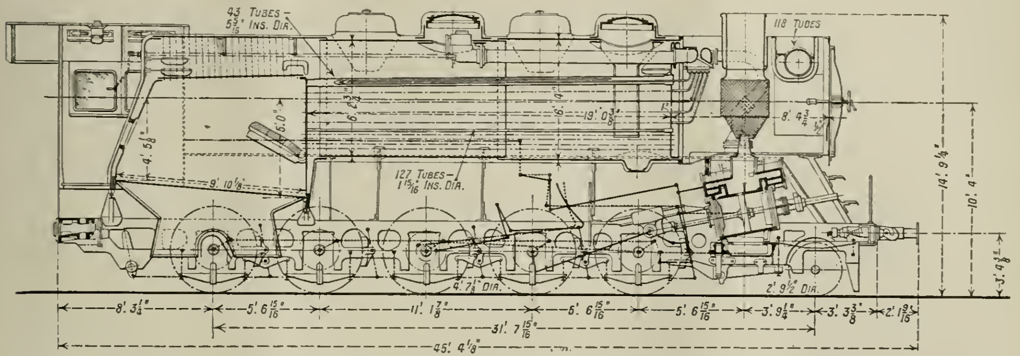
placed between the frames are inclined. These cylinders form one casting with their respective steam chests. The low-pressure cylinders placed outside the frame are horizontal.

Steam distribution is effected by means of piston valves with small spring packing rings. The high-pressure valves of 8⅝ inches diam. have inside admission, and the low pressure valves of 13¾ inches diam. outside admission. They are actuated by the standard Heusinger valve gear with transmission shafts for conveying motion from the outside to the inside valve spindles. On the steam chests are by-pass valves controlled by air, and on the cylinders the usual drain valves and safety valves. The high-pressure by-pass valves, when open, also serve as starting gear, the steam flowing direct through the steam chests of the high-pressure cylinders to the low pressure cylinder. In the case of the two cylinder locomotive, the cylinders measure 25.6 inches diameter by 25.9 inch stroke, and the piston valves are 11¾ inches diameter.

The following are the principal dimensions:

Cylinders (two) H.P. diam.	18⅛ in.
" (two) L.P. diam.	28⅜ in.
" piston stroke	26 in.
Wheels, coupled, diam.	6 ft. 6¾ in.
" bogie, diam.	2 ft. 9½ in.
" trailing, diam.	4 ft. 1¼ in.
Wheelbase, rigid	15 ft. 1⅛ in.
" total	40 ft. 8¼ in.
Steam pressure	227.6 lb. per sq. in.
Heating surface—	
Firebox	182.9 sq. ft.
Tubes	2,377.96 sq. ft.
Total	2,560.88 sq. ft.
Superheater	1,076 sq. ft.
Preheater	144.184 sq. ft.
Grate area	48.5 sq. ft.
Weight in working order (engine)	
Adhesion weight	
Weight in working order (engine and tender)	175 tons
Tractive power	26,400 lb.
Tender	
Wheels, diam.	3 ft. 3⅜ in.
Wheelbase, total	15 ft. 7 in.
Water capacity	7,000 gallons
Coal capacity	7 tons
Weight in working order	64.062 tons

All wheels of the coupled axles and also those of the bogie are braked on one side by air brakes of the Knorr type, the brake power available being equal to 170 per cent of the adhesive weight and 70 per cent of the weight borne by the trucks. The tender is equipped with a Kunze-Knorr pressure brake, as well as hand brake. Furthermore, the driving and coupled wheels are sanded by means of an air sand blower. The locomotive also possesses steam-heating apparatus, gas-lighting and speed-indicating mechanism. The tender is carried on eight wheels, the leading pair of axles being mounted in a bogie, whilst the trailing pair are rigid with the main frames.



Standard Three-Cylinder Simple 2-10-0 Heavy Freight Locomotive for the German State Railways

2-10-0 Heavy Freight Engine

The heavy freight engine of the 2-10-0 type with three single expansion cylinders represents the latest development in size in Germany. As the drawing shows, the inside cylinder is inclined and drives the second pair of coupled wheels and the outside cylinders are horizontal and drive the third pair of coupled wheels. The boiler is substantially the same as that fitted to the passenger engine previously described, as also is the general equipment of the locomotive.

Steam distribution is effected by piston valves 11¾ in. in diameter, the inside valve being actuated by mechanism deriving motion from the outside valve spindles. The arrangement of steam and exhaust piping is shown in the cross-end sectional view, which similarly demonstrates the location of the steam chests to the cylinders. The latter are 23⅝ in. diameter, the piston stroke being 26 in., other particulars being as follows:

Heating surface total	2,551 sq. ft.
Superheater	1,076 sq. ft.
Grate area	50.6 sq. ft.
Working pressure	200 lb per sq. in.
Weight in working order	111.65 tons
Tractive power	47,100 lb.

The tender is mounted upon two four-wheeled bogies, with wheels 3 ft. 3⅜ in. in diameter. It has a coal capacity of 9.842 tons, and a water capacity of 7,000 gallons. Its weight in working order is 75.22 tons, making a total for engine and tender together in working order of 186.87 tons.

The 2-10-0 type freight locomotive will be employed hauling trains of 2,000 tons or more equipped with continuous brakes and made up for the purpose of long through runs.

We are indebted to our esteemed contemporary, The Railway Engineer of London, England, for the data and illustrations in regard to these locomotives.

Means of Preventing Boiler Pitting

By C. H. Koyl, Engineer Water Service, Chicago, Milwaukee & St. Paul Railway

A few years ago it had become apparent to all students of the subject that boiler pitting is originated by electro-chemical forces, but that its continuance beyond very early stages, in any but acid water, is dependent on the presence in the water of dissolved oxygen.

In April, 1925, this journal published a paper of mine outlining the theory for railroad men and stating how it might most easily be demonstrated in practice in locomotive boilers.

The theory is that the results of the electro-chemical action are the solution of iron in the water and the coating of he electro-negative surfaces with a film of hydrogen, and that both these conditions tend to stop pitting (1) because the water soon becomes saturated with iron and (2) because the layer of hydrogen soon stops the electric currents which are a necessary part of the series of operations which result in pitting; but that dissolved oxygen will combine chemically with both dissolved iron and hydrogen, and allow pitting to proceed.

The paper stated that, so far as railroad men are concerned, these conclusions were the result of following up the discovery that in properly softened water locomotive boiler pitting occurs only in the front end of the boiler, that the disappearance of oxygen to the steam-space is the only possible explanation and that this might be proved by fitting a locomotive boiler, running in such water, with an open feedwater heater which would expel most of the oxygen before the water reached the boiler and prevent all pitting.

Before making the test I wrote to other railroads which had used these heaters for months to inquire their experience in reducing pitting. The answers all were that no reduction in pitting had been observed, but that this meant little because their attention had been confined to coal-and-water saving and the workability of the heater in practice.

Of late several papers have appeared (Railway Review, 1926, Barr June 5, Pownall August 21, Gunderson September 4, Speller September 11) all written by men of knowledge and keen observation, all emphasizing the controlling influence of dissolved oxygen in sub-aqueous corrosion, but all accepting the negative results of the above paragraph, and all regretting that it is not yet possible to equip a locomotive with a satisfactory oxygen-expelling heater.

On the other hand, my report printed in this journal for September, just to hand, states that a locomotive equipped with an open feedwater heater has been running on our worst pitting district (pitting bad in spite of water treated down to a hardness of two grains per gallon and carrying caustic soda in excess) continuously for one year without a sign of pitting, while her mate, without a heater, running in the same water and under the same conditions has lost twenty-five of her tubes to the scrap heap with others on the way.

This calls for explanation, and I propose to show (1) that it is easier to exclude oxygen from a locomotive boiler than from a stationary boiler or any closed water system, (2) why no one else has reported a diminution of pitting, (3) that on districts with treated or naturally soft water there is no difficulty in preventing pitting with the present open heater nor in materially reducing it by a closed heater or even with a closed-overflow injector properly chosen and properly operated.

(1) It is well known that locomotive boilers with new flues do not pit in mountain water; but everyone connected with the roads on the Western coast remembers what happened in 1909 when Mallet engines with closed feed-water heaters on the front ends of the boilers were introduced. These heaters were always absolutely full of water, so that neither was the least surging nor the escape of any air possible, and everyone of those heaters was pitted to scrap in a few months. There was nothing in the water except carbon dioxide and oxygen but, on account of the size of the heater, there was time for every atom of gas to get in its work and it is probable that it would have been necessary to exclude all the oxygen to prevent pitting.

In the case of stationary boilers, there is a steam-space and considerable bubbling of the water to help free dissolved gases, but it is probable that 90 per cent of the oxygen must be excluded to prevent pitting.

In the case of locomotives, the boiling is many times faster than in stationary boilers and there is not only violent bubbling but continuous surging, and it is certain that a much less careful exclusion of oxygen will be sufficient. It should be remembered that in ordinary railroad practice water heated by an injector releases its oxygen to the boiler steam-space so rapidly that in true alkali-boiler-water pitting in a locomotive is seldom found back of the middle of the flue.

In this open locomotive feedwater, water from the engine tank is forced into the heater in a spray, so that in this finely-divided condition it meets the mass of exhaust steam from the cylinders and its gases are easily freed and discharged through the vent-pipe. Pressure in the heater from the exhaust steam (when the engine is working) is always at least 4 to 5 pounds per square inch and the discharge of gases is continuous and free. There is therefore every *a priori* reason to believe that the use of such a heater will reduce the oxygen content of the water sufficiently to prevent any pitting.

(2) Then why has not even a reduction of pitting been reported from some of the 1,800 heaters in use on other roads?

(a) In most of these cases the water is heated only by exhaust steam (the original intent of the heater was to save coal and water by utilizing the otherwise wasted heat in the exhaust steam) and when standing at stations water, if needed, must be taken through the injector or taken cold through the heater, in either case taking oxygen with it into the boiler.

(b) In drifting very little steam is being used, but the heater is sometimes kept working, and oxygen-charged water goes into the boiler.

(c) In hill climbing, it frequently happens that the heater cannot keep up the water supply and the injector is used also.

(d) Water level in the heater is maintained about halfway up by a valve which slides on a rod. Sometimes, if a little scale gets on this rod, the valve sticks and the water level rises until the heater is full and there is no vent for the gases.

(e) Cold water from the engine tank to the heater and hot water from the heater to the boiler are handled by two pumps in the heater, one working against very low pressure, the other against boiler pressure. If the cylinder packing in the hot-water high-pressure pump is allowed to deteriorate, it may easily happen that the low pressure pump delivers the more water, with the flooding of the heater and perhaps of the engine cylinders.

Such details of operation and maintenance I explained to our men when the heater was put into service, and the result has been the operation of this heater-equipped engine for 18 months with no troubles. The flues have been examined every three months, and we have found no signs of pitting; last week the interior of the heater was examined and no pitting found even on the machined surfaces.

One hears talk now and then of other materials in boiler water which can produce the effect of oxidation, and while the statements are technically correct the amount of such materials is like the gold in sea water, not worth bothering about. It is my present belief that if oxygen is excluded from boiler water there will be no pitting, regardless of the kind of water and the kinds of metal in the boiler; and that to exclude oxygen from a locomotive boiler is about the simplest thing in the world.

It has been evident for several years that the high temperature of injector water as it enters the boiler has much to do with the early escape of oxygen to the steam-space, and almost certainly there is some temperature above 210 deg. F. and below 300 deg. at which if entering water could be constantly maintained the dissolved gases would rise to the steam-space so quickly as to reduce pitting materially.

A few weeks ago I was invited to explain the absence of pitting on the flues from a locomotive boiler which had been in service one year on a bad pitting district and showed no deterioration whatever. It turned out that the engine had been running under such conditions that the injector could be kept in continuous action if the water supply were throttled down to much less than maximum capacity. It appeared that this had been done quite regularly, and since the temperature of the water at the check valve varies from 160 deg. to 300 deg., according to whether the injector is working at full capacity or is throttled down to perhaps 40 per cent of water capacity, I take it that the average temperature of water entering this boiler was high, perhaps 250 deg., and that this accounts for the freedom from pitting of this boiler.

A closed feedwater heater should maintain an average temperature considerably higher than that of usual injector water, and therefore liberate the oxygen more quickly.

It appears to me to be a very simple matter to eliminate pitting (1) probably by using an over-sized closed-overflow injector so that the proportion of water to steam will be small and the resulting temperature high; (2) probably with a closed heater because of high temperature and with the great advantage of coal-and-water saving; (3) certainly with an open heater, with all these advantges and its latest improvement of a live-steam connection for heating the water when standing or drifting.

The above remarks apply, I believe, to all soft waters either natural or treated; but there may be difficulty from foaming if feedwater temperatures above 210 deg. are used with hard waters. In such case there will be precipitation of specs of calcium carbonate in the feedwater, than which there is no greater stimulant to foaming, as has been found in the early use of all locomotive feedwater heaters.

Largest Storage Battery Locomotive, with Gas-Electric Auxiliary

The largest storage battery locomotive in the world, weighing 110 tons and capable of hauling a 1,500-ton train, equivalent to 70 empty or 30 loaded freight cars, at a speed of from eight to 10 miles an hour, is now in service in Chicago. Pulling a passenger coach, carrying railroad engineers and officials as well as representatives of the General Electric and Electric Storage Battery Companies, designers and manufacturers of the locomotive, it made the 450-mile trip from the Erie, Pa., works of the General Electric Company under its own power, with a stop at Cleveland for exhibition at the American Electric Railway convention.

This unit has many of the advantages of the usual electric locomotive without requiring an overhead trolley of third rail for its source of power. It will be used for some time in the freight yards of the Chicago and Northwestern Railway to demonstrate its possibilities in solving some of the problems of railroad terminal electrification in that city. The locomotive, incorporating features of both the storage battery and the gas-electric drive, has a number of novel features which make it particularly adaptable to switching service.

The control is so arranged that power can be taken entirely from the storage battery, or the gas-electric drive can be used. If more power is needed than is being supplied by the gas-electric unit, the storage battery supplies energy in parallel with the engine-driven set; if the gas-electric unit is supplying more power than is required by the motors, the excess automatically charges the storage battery. In switching service, the battery can thus be used to supply power, with the gas-electric unit used during slack periods to keep the battery charged. The storage battery can also be recharged by outside power.

It is intended to use the storage battery as the source of power for the traction motors under ordinary circumstances. The proportions of these batteries have been selected so that under ordinary conditions of switching operation the battery will furnish sufficient electric power to handle the locomotive for one day's service without recharging. The entire space in the two sloping auxiliary end cabs is devoted to this battery equipment. The battery is made up of 120 cells, type FL-31, Exide Iron Clad, with a capacity of 616 kilowatt-hours, and capable of charges of rates up to 846 kilowatts. These storage batteries, the largest ever manufactured for this purpose, can deliver 1,000 horse-power to the driving motors, a feat which can be done by no other type of self-propelled locomotive of equal weight.

The auxiliary gas engine generating set, provided for recharging the batteries, permits the locomotive to be kept in continuous service and operated, if necessary, on tracks remote from the regular charging facilities. Under ordinary switching service in Chicago, the battery will be charged from special equipment installed by the Commonwealth Edison Company in the freight yards. At night, or at other times when the locomotive is idle, the battery can be connected to the power company's regular lines for a recharging.

The gasoline engine set is known as the Winton model 106-A power plant. The engine is a six-cylinder, 1,000-r.p.m. unit with 7¼ in. by 8 in. cylinders. The generator, built by the General Electric Company, is a type DT-508-A shunt-wound machine designed to supply 230 volts. A radiator of the fin tube type is mounted on the roof of the central cab, and forced ventilation is provided by two motor-driven fans. A pump, driven directly by the engine circulates the cooling water, and for protecting the cooling system against freezing when the engine is idle in winter, a small coal-fired heater is provided. Suitable valves and piping connections are supplied for passing the hot water through radiators located at each control station, thus providing heat for the cab during cold weather. A 150-gallon fuel tank is suspended underneath the platform. The gasoline feed to the carburetor is effected by a magnetically operated diaphragm pump.

Each of the four axles of the locomotive carries a GE-287 motor driving through a single reduction gear. The gear reduction is 66/16. The motors are of the longitudinally ventilated construction, and provision is made for forced ventilation.

The control is of the PCL single-unit double-end type, providing nine resistance points, one free running point and one reduced-field point with the motors in series parallel. With a full multiple grouping of the motors, there are seven resistance points, one free running point, and one reduced field point. A reversal of operation is obtained by an electromagnetic switch which reverses the motor fields.

The battery is divided into two sections, connected in series during locomotive operation and when charging from the gas engine side on the locomotive. A manually operated series-parallel switch provides connections for charging the battery from an external source with the two sections connected in parallel. Suitable interlooks insure against the possibility of improper operations.

An ampere-hour meter automatically opens up the charging circuits when the battery is fully charged, and shuts down the gas engine if the charging current is being taken from the auxiliary side.

Separate watt-hour meters measure the power consumed by the locomotive, the input from the generator, and the input from any external charging circuit. Ammeters are also provided for indicating the motor and generator current.

Type No. 14EL straight and automatic air brake equipment is provided, the air being furnished by a CP-26, 100 cubic foot compressor.

The locomotive is of the steeple-cab type, with two swivel motor trucks. The platform is built up of structural steel having channel side sills and I-beam center sills. The couplers carried at each end of this platform are A.R.A. friction draft gear with 5 in. by 7 in. shank. The trucks are rigid bolster, equalized type with side frames of rolled steel plate.

The cab is made up of a central section containing the two control stations, contactors, resistors, relays and other auxiliary control equipment and the gas-engine generator set and air compressor.

Within the past few years, storage battery locomotives have been developed until they are fast becoming a definite factor in modern transportation. Locomotives of a similar type but smaller have been in successful operation for several years in industrial plants.

The problem of electrifying the railroads in Chicago has been studied by most of the prominent electrical and railroad engineers of the country during the past decade. It is the opinion of many of these engineers that storage batteries can be used to advantage in propelling switching locomotives in many locations in Chicago.

The following table gives the principal weights, dimensions and other data for this locomotive:

WEIGHTS

Locomotive complete	237,000 lb.
Mechanical equipment	100,700 lb.
Battery	78,960 lb.
Motor	29,800 lb.
Engine and generator	7,850 lb.
Radiator and fan	3,500 lb.
Control	9,150 lb.
Brakes	5,640 lb.
Heater	1,400 lb.

DIMENSIONS

Length overall	52 ft. 0 in.
Wheel base	39 ft. 0 in.
Rigid wheel base	8 ft. 0 in.
Height	14 ft. 8 in.
Width	10 ft. 0 in.

Tractive effort, one hour capacity, 17,200 lb.

Speed at one hour rating, 9½ m.p.h.

Tractive effort, 30 per cent coefficient of adhesion, 66,000 lb.

Maximum speed, 30 m.p.h.

Time motors will carry max. tractive effort, 9 minutes.

Cylinder Contents

The accompanying table gives the volume swept through by the piston of locomotive engines on a single stroke, for sizes varying from a diameter of 17 in. and a piston stroke of 24 in. to a diameter of 32.5 in. and a stroke of 32 in. In using this table for estimating the amount of steam used an addition must be made for clearances which can be added in percentage. The approximate weight of steam used by the large locomotives can be readily calculated and becomes rather impressive. Take for example such a moderate sized engine as a 25 in. by 28 in., when running at 50 strokes per minute, and using superheated steam at a pressure of 200 lb. per sq. in. and a superheat of 160 degrees Fahr. it will require about 650 lb. of steam per minute.

Cylinder Diameter Inches	Piston Stroke in Inches								
	24	25	26	27	28	29	30	31	32
17.0	3.152	3.284	3.415	3.547	3.678	3.809	3.941	4.072	4.203
17.5	3.341	3.479	3.619	3.758	3.897	4.037	4.176	4.315	4.454
18.0	3.534	3.681	3.829	3.976	4.123	4.271	4.418	4.565	4.712
18.5	3.733	3.889	4.044	4.200	4.355	4.511	4.667	4.822	4.978
19.0	3.938	4.102	4.268	4.430	4.594	4.758	4.922	5.086	5.251
19.5	4.148	4.321	4.493	4.666	4.839	5.012	5.185	5.352	5.531
20.0	4.363	4.545	4.727	4.909	5.148	5.272	5.454	5.636	5.818
20.5		4.775	4.966	5.157	5.348	5.539	5.730	5.921	6.112
21.0		5.001	5.211	5.412	5.612	5.813	6.013	6.214	6.414
21.5		5.252	5.462	5.673	5.883	6.093	6.303	6.513	6.723
22.0		5.499	5.720	5.940	6.160	6.380	6.599	6.820	7.040
22.5		5.752	5.982	6.213	6.443	6.673	6.903	7.133	7.363
23.0		6.011	6.251	6.492	6.732	6.973	7.213	7.454	7.694
23.5		6.273	6.526	6.777	7.028	7.279	7.530	7.781	8.032
24.0		6.545	6.806	7.069	7.334	7.592	7.854	8.116	8.378
24.6		6.821	7.093	7.366	7.639	7.912	8.185	8.457	8.730
25.0		7.102	7.386	7.670	7.954	8.238	8.522	8.806	9.090
25.5			7.684	7.980	8.275	8.571	8.866	9.162	9.458
26.0			7.988	8.296	8.603	8.910	9.218	9.525	9.832
26.5				8.612	8.937	9.256	9.578	9.895	10.214
27.0				8.946	9.278	9.609	9.940	10.271	10.603
27.5					9.624	9.968	10.312	10.656	10.999
28.0					9.978	10.334	10.690	11.046	11.403
28.5					10.337	10.706	11.075	11.445	11.814
29.0					10.703	11.085	11.467	11.850	12.232
29.5					11.075	11.471	11.865	12.262	12.657
30.0					11.454	11.863	12.272	12.681	13.090
30.5					11.839	12.262	12.684	13.107	13.530
31.0					12.230	12.667	13.104	13.540	13.977
31.5					12.628	13.079	13.530	13.975	14.432
32.0					13.032	13.497	13.965	14.432	14.894
32.5					13.442	13.922	14.402	14.882	15.363

Volume Swept Through Cylinders in Single Stroke of Piston

Electrification of the Southern Railway in England

Further electrification of Southern Railway in England has been announced. The scheme comprises the installation of the direct current third-rail in substitution for existing overhead electric system on 127 single-track miles. The electrified third rail is also to be laid over 105 single-track miles of suburban railway at present worked by steam. Total track mileage involved amounts to 232, exclusive of sidings. The total cost of the extensions is estimated at $3,750,000, and it is anticipated that all equipment will be British.

"The Locomotive of Today" Discussed in a Series of Papers to the Traveling Engineers Association

The Traveling Engineers' Association held its thirty-fourth annual convention at Chicago, September 14 to 17 inclusive. The convention brought together about two thousand road foremen of engines, mechanical and operating officers. The machinery and equipment exhibits were the largest ever held in that city.

The "Locomotive of Today" was the subject of a group of papers treating the importance of improvements in design to increase reliability and decrease the cost of maintaining.

The committee reports were prepared on the following subjects: Smooth Train Handling, Practical Instruction for New Firemen, Revision of Progressive Examination for Firemen for Promotion and New Men for Employment, Locomotive Availability in 100 per cent Condition, Up-to-date Engine House and Terminal Facilities and Methods.

Individual papers were read by T. A. Talty, special engineer, Franklin Railway Supply Co., "The Locomotive Booster," W. L. Hack, superintendent Southern Pacific Company, on "How Can the Traveling Engineer Cover His Growing Job"? Roy Liston, mechanical inspector, Atchison, Topeka & Santa Fe Railway.

Among the speakers were A. G. Pack, chief inspector bureau of locomotive inspection, Interstate Commerce Commission; W. L. Bean, mechanical engineer, New York, New Haven & Hartford Railroad; J. B. Ennis, vice-president, American Locomotive Company; W. T. Woodward, vice-president, Lima Locomotive Works; C. T. Ripley, chief mechanical engineer, Atchison, Topeka & Santa Fe Railway; O. S. Jackson, superintendent of motive power and machinery, Union Pacific Railroad; W. G. Black, superintendent motive power, New York, Chicago & St. Louis Railroad; A. G. Trumbull, chief mechanical engineer, Erie Railroad; Frank McManamy, Interstate Commerce Commission and John E. Muhlfeld, consulting engineer, New York.

The convention was called to order by President J. N. Clark of the Southern Pacific, who, after the invocation and welcome of the city, addressed the members as follows:

President Clark's Address

"During the past year it became my pleasant duty to select two committees from our membership to co-operate with the American Railway Association's committees on Locomotive Utilization and Locomotive Construction and Design. Invitations have been extended to the chairman and members of those committees to attend our convention. The very friendly attitude of Mr. Aishton and other officers of the American Railway Association is, I am sure, very much appreciated by this association.

"The responsibility of the traveling engineer increases with the ever-increasing demand for better transportation. Coming within our immediate supervision is a vast army of 133,000 locomotive enginemen and firemen who look to us for education, guidance and inspiration. Our managements look to us for expert advice on everything that pertains to the modern locomotive, proper distribution of power to serve the industry best, advice upon all new locomotive appliances, fuel economy and smooth train handling to insure a safe and on-time performance.

"Seven new records were established by the railroads of the United States in 1925. Included in this remarkable performance are several records over which the traveling engineer has direct supervision. Are we not, therefore, justified in feeling proud of these accomplishments? Our records mean nothing to Mr. Aishton; he makes them today, only to break them tomorrow.

"But don't you get a 'kick' out of breaking records? Let us pick up enough new ideas during the next four days to go home and smash all the records he can put up for us to shoot at during the next 365 days.

"Progress means going forward and civilization has shown the greatest progress where transportation has been developed to its highest efficiency. China, with a population of 400 million, has less than 7,000 miles of railroads to serve its four and a half million square miles of territory, while the United States, with a population of 116 millions, has over 250 thousand miles of railroads to serve its three million square miles of territory. Transportation has been the big civilizing influence in ours, and every other country, and we should feel a just pride in our contribution to such an industry.

Economic Necessity Controls Developments

By J. E. ENNIS, Vice President American Locomotive Company

The locomotive of to-day is a vital factor in the prosperity and success of the railroads of the country. It is in no small measure responsible for the very gratifying results obtained in recent months by our railroads. All of us who are fortunate enough to have spent some of our lives in the operation and design of this machine are justly proud of the position it occupies.

This locomotive of to-day is the most efficient motive power unit in railroad history. It has been more than a century in the making, and the fact that it resembles, in many respects the first successful attempts at rail locomotion makes it quite proper that we should acknowledge the soundness of the basic principles, established by those eminent engineers responsible for the introduction of this means of transportation.

These basic principles are still embodied in the steam locomotive of to-day, and, to some extent, in other forms of rail power. During this century of steady progress in locomotive development many refinements and improvements have been made, and the modern locomotive stand out as the greatest revenue producing motive power unit ever constructed.

Probably never before in the history of railroading has there been the necessity of using efficient power units as there is to-day. We have had, in this country, enormous increases in the cost of fuel, labor and other materials necessary to railroad operation. Along with this, we have freight rates that have not been increased in proportion to expenses. How, then are the railroads to make adequate return to the owners? We know that most of them, until very recently, have had great difficulty in doing so. With business and fairly heavy traffic, the problem calls for expert handling. When crops are bad, general business poor and traffic falls off, it is only by the most

careful operation that the railroads are able to make both ends meet.

We have seen, during the first six months of this year, a record performance by our railroads. According to the figures recently published by the Bureau of Railway Economics, they have shown better earnings than ever before. How was this accomplished? Not by allowing the existing machine to function as when better conditions prevailed, but by speeding up, by elimination of waste of time and material, by prevention of duplication in operation, by a better spirit of cooperation between the worker and the executive, which brings about greater efficiency through the absence of friction, and all of this through the wise leadership of the ablest, most constructive and the most human railroad management of all time.

The part that the locomotive of today plays in the railroad problem is an important one. It is the mechanical force that keeps our traffic in motion. It represents a large investment.

Railroads are intended, first, to serve the public, and, then, to yield an adequate return to their owners. Even if they are in good physical condition, without proper motive power, they cannot serve the public as they should; nor, under present conditions, can they give a proper return to their owners. Railroad management, therefore, has a right to expect, and must insist, that motive power purchased must be of such design and construction as will produce maximum sustained power on minimum fuel consumption and maximum mileage in minimum time with low maintenance cost. The locomotive of today is a machine that fulfills these requirements, and records of recent months show performances that reflect strongly in improved earnings, in a better satisfied shipper, and, in general, a better service to the public.

During the past few years, there has been a very intensive development of the locomotive, not only abroad, but in this country as well. On account of rising taxes, cost of fuel, and other expenses, railroad managers the world over have seen the absolute necessity of conserving fuel and material, and of handling all possible traffic offered or obtainable. In fact, realizing the maximum production from the existing railroad machine. The result of this situation has been the upbuilding of the roads in general from a physical standpoint, permitting of greater utilization of the property, and, along with this, comes the necessity for locomotives that would keep pace with the greater demands of the service. Railroad managers, motive power officials, and locomotive builders have been alive to this situation, and, recently, have been cooperating to the fullest extent.

For many years, designers of locomotives were concerned primarily with increasing the power of the individual unit. Millions have been spent in laying heavier rails, strengthening bridges, and providing better facilities to permit of more powerful machines being used. We would not say that limits had yet been reached in this respect and, yet, we feel we have provided unusually powerful locomotives within the existing clearance limitations. What we are striving for now is increased power, but measuring it on a time and fuel basis. This means a locomotive that will give high starting effort, and maximum sustained power to haul heavy tonnage trains at high speed over long distances.

The increased cost of fuel has made it necessary for us to consider this item as most important. Last year, the railroads of this country spent more than $300,000,000 for fuel for their locomotives. And, as this represents such a large proportion to total expenses, it is only proper that all possible sources of economy be thoroughly taken advantage of.

What is the locomotive of today, in general? We have at the present time, three distinct classes. Steam, electric and internal combustion. Since the advent of railroading in this country, the steam locomotive has been predominant, and still continues to be. While you men are primarily interested in the steam locomotive, it is needless to deny the advantages of any one of the three classes mentioned.

Within the past twenty-five years, the development of the electric locomotive in this country has progressed steadily and still, more recently, the internal combustion locomotive has entered the field and promises to remain with us. Certain conditions favor for safe and profitable operation the electric locomotive. Still others can be more advantageously met by the oil locomotive.

There is no need of my mentioning the many electrification projects that have been carried out in this country. The most important ones are probably on the New York Central, Pennsylvania, New Haven, St. Paul, Norfolk and Western, Virginian, Illinois Central, Southern Pacific, B. A. & P. Of the improvements today in the design of electric locomotives as compared with those of several years ago, I am not prepared to speak in detail. It is safe to say, however, that those responsible for the design of electric locomotives have had the same purpose in mind as the steam locomotive designer. That is, better utilization of the locomotive and, without any doubt, the electric locomotive as designed and built today is a most reliable piece of machinery with remarkable freedom from either mechanical or electrical troubles, and capable of heavy continuous duty with a mimimum of maintenance expense.

The electrification of a railroad division means an enormous investment as compared with steam operation which cannot be justified unless there are peculiar conditions particularly favorable to this method of transportation. Even then, the probable economies should be investigated thoroughly to make sure that the financial return will not be in doubt. Careful consideration should be given also to the possibilities of economizing and obtaining greater capacity by the use of improved steam locomotives where the investment would not be so great and the results can be forecast with reasonable accuracy. Unfortunately, some comparisons have been made to prove the superior economy of electrification where they have been based upon steam operation with locomotives of old design, and in many cases, very light power. The modern steam locomotive has shown such an improvement in productive capacity and economy, even over locomotives of ten or fifteen years ago, as to warrant its continued use for many years to come for the general service of our railroads.

There are many difficulties in the way of providing an internal combustion locomotive to replace the modern high powered steam locomotive, although, ultimately, the problem will be solved if there is sufficient demand, and if it would appear to be an economical necessity. Until this is done, large power in this class can only be obtained by the coupling together of two or more smaller units, and the use of multiple control, which is entirely feasible. Our experience so far with this class of power has been confined to comparatively small units, mostly for switching service. Locomotives are now being built for branch line service of somewhat higher power and designs are being prepared for still larger units. All of the oil locomotives so far built in this country for railroad operation have been constructed with electric transmission. Experiments are being made, both here and abroad, with other forms of transmission, such as hydraulic and mechanical, and the question of the most satisfactory drive is only one of the many problems yet to be solved. The great advantage of such a locomotive lies in the economy in fuel, the

elimination of the boiler with its maintenance troubles, and the possibility of almost continuous daily use. With a thermal efficiency, conservatively stated, of twenty per cent as against an approximate maximum of eight per cent for the existing steam locomotive, one might well ask why the internal combustion locomotive will not immediately supplant the steam locomotive. Some of the best engineering talent in the world is busy on this problem. A large amount of money will have to be spent before locomotives of this class will be able to compete with the steam locomotive from the standpoint of maximum power within existing clearance limitations and allowable weights. Fully recognizing the advantages, including the great saving in fuel, there are many obstacles in the way, although it has proved its reliability in the service in which it has so far been engaged, and gives great promise.

Coming now to the steam locomotive, I would like to read a paragraph from the Proceedings of the Western Railway Club of March, 1894.

> "The most encouraging thing, I think, that we have in the matter of compound locomotives, is the report from the Pennsylvania road, where they show at 70 miles per hour they have developed 914 horse power. I think that is the most remarkable record that I ever heard of a locomotive having made. It is the greatest horse power, I think, that has ever been reported at such a high speed. That has been accomplished with a compound locomotive, and it shows that the distribution of steam in that type may enable us to develop this high power at high speeds where it could not be obtained in a simple engine."

That evidently represented a maximum locomotive of that time from the standpoint of horse power. A few years later, or in 1906, the statement was made at one of our eastern railroad clubs by an earnest advocate of electric traction that electric locomotives then in service had developed a horse power at the wheels of 2,500 to 3,000, something that never could be accomplished by the steam locomotive. Today, we have clearances very little in excess of those of thirty years ago, and yet our steam locomotive is a machine that develops more than 3,500 indicated horse power. In fact, one of our largest freight road locomotives recently built developed in excess of 4,700 indicated horse power. This achievement has been a gradual one. It has not been easy and neither has it been accomplished through the efforts of the builders only. We have been assisted by heavier rails, better road bed and improved facilities. We have had the cooperation and encouragement of progressive railway management and motive power officers, and the aid of the builders of equipment accessories.

It has been difficult to provide these large increases in power and at the same time to improve fuel economy. Stationary power plants are often compared with the locomotive power plant from an efficiency standpoint.

In speaking of fuel economies as compared with power plants, it should be remembered, however, that the power plant is usually working at an ideal speed for economy. The locomotive, if operated at its ideal cut-off continuously, would show marked economies in operation as compared with present day use. This, of course, is not possible. Stationary power plants, in general, have no such physical restrictions as the locomotive is confronted with. There are no weight limits imposed. Clearances are very elastic. Grate areas and boiler sizes can be made anything the designer desires. This is not possible in a locomotive. We have probably reached our limits in boiler sizes for locomotives. We have grate areas today as large as 115 square feet, boilers 57 feet long, and some 118 inches in diameter at their largest part. The famous New York Central 999 had a boiler that weighed about 39,000 pounds in working condition—that is, with water. The weight of a boiler on one of our largest locomotives of today in similar condition is 172,000 pounds. If we took the boiler tubes in the 999 and laid them end to end they would reach 3,237 feet. In the recent three cylinder freight locomotive built for the Union Pacific, the tubes, flues and superheater pipes, if placed end to end, would reach about three miles. This gives a picture of the steam locomotive today from the standpoint of size.

From the standpoint of power, we have reached 96,600 pounds tractive effort in a simple locomotive of the three cylinder type, giving a maximum horse power of 4,750, and yet have been able to keep bridge and track stresses as low as in the case of smaller and less powerful machines operating in similar service.

Several years ago, we were too apt to measure a locomotive in terms of tractive power only. New locomotives were bought having so many thousand pounds more tractive power than some previous lot. In only too many cases, it was found that the result was an under-boilered locomotive, or one that was too slippery to utilize fully the increase in power. Today, we concern ourselves more as to sustained power or the ability to take heavy tonnage trains and keep them going at a good rate of speed. In other words, to produce more gross ton miles per train hour. If you will compare the results obtained in recent months with those of a few years ago in this respect, you will find a much greater increase in output of this character than the mere increase in tractive effort would indicate.

Among the fundamental improvements recently made in this country in the steam locomotive through the cooperation of the motive power officers of the roads and builders might be mentioned the following:

Application of three cylinders, both simple and compound.

High boiler pressure now reaching 400 pounds per square inch.

Limited cut-off.

Higher temperature superheaters.

Water tube fireboxes.

Large tenders.

Twelve coupled locomotives.

Improvements in details tending to give greater reliability with less maintenance.

Improvements in counterbalance and other conditions making for lower rail stresses.

As builders we have been constantly aiming to advance the art. Each builder has his own ideas as to the particular characteristic of design that will best fit certain conditions and provide the most efficient machine. Each one has demonstrated under certain condition that his theories were correct. It is perhaps best that this rivalry or pride in individual organizations exist. There is no doubt but what greater progress will be made in this manner, and it is safe to say that the ideas advanced by each builder are sane, and not thrown out for general use to the railroad operators until it has been demonstrated that there is sufficient merit to warrant it. Each builder is trying to put out the best that he knows how from a designing and construction standpoint, in order to provide the maximum of efficiency, economy and serviceability.

The builders have, in a few cases, brought out for experimental purpose single locomotives designed with the thought of providing increased sustained power, greater economy in fuel and greater reliability in service. These have demonstrated the possibilities of reducing operating costs through the replacement of obsolete and inefficient power. New locomotives and old designs will take care of increases in traffic, but will not show the economies in operation that are shown by these improved designs.

A little more than three years ago, we were confronted with the problem of providing, in a given case, considerably more power within certain restricted clearances and

weights than had been previously possible. At that time there seemed to be only one way out of the difficulty and that was the introduction of a third cylinder. This was not new, having been unsuccessfully tried many years before in this country and yet, more recently, abroad with considerable success. There were many obstacles in the way, but we felt that the trouble heretofore experienced with this class of locomotive could be overcome. This first application was on an existing locomotive, and while the cylinders were made three inches smaller in diameter than in the case of the two cylinder engine the maximum tractive force of engine was increased from 54,000 to 64,500 pounds. The same size boiler and firebox were utilized and in order to provide for better steaming qualities and higher superheat a new design of superheater was installed. The rebuilding of this locomotive demonstrated the practicability of the design and further proved that increased power could be obtained in this manner without involving greatly increased stresses. Since the completion of this first locomotive, we have supplied a total of 141 locomotives of the three cylinder type. A considerably larger number is in successful service abroad. The performance of these locomotives has proved to our satisfaction that in general for the same weight on drivers an increased hauling capacity can be obtained, varying from 11 to 20 per cent. The advantages, other than the increased power, being better balancing, better steaming of the boiler due to six exhausts instead of four. Lower piston thrusts, fuel economy, and better effect on track. The maintenance costs so far do not indicate any appreciably higher amounts than those of corresponding two cylinder engines. The latest developments in this class of power are the locomotives recently delivered to the Union Pacific of the 4-12-2 type. One of these having been in service since last May and the others just now going in service.

Another recent development is the three cylinder mountain type locomotive built for the New Haven, having water tube fireboxes and carrying a working pressure of 265 pounds.

The steam locomotive must be improved from the standpoint of thermal efficiency, in order to remain as it is at present, predominant in its field. Even though most of the locomotives now in service in this country are of the two cylinder single expansion type, this does not mean that the steam locomotive of the future must be of that type.

Fuel is becoming too costly to permit of this design of locomotive to continue as the ultimate providing that some more economical method does not introduce too many complications, resulting in heavy maintenance charges. The fact that many years ago, we tried compounding, and discarded it because of its complications, does not necessarily mean that we must be content with single expansion for the future. As a matter of fact most of the fuel saving devices in use to-day were tried many years ago and many were discarded because the fuel economy realized at that time did not warrant the expense of arranging for systematic maintenance. This condition is different to-day. When we had compound engines, we did not have high priced fuel. There was not the incentive to overcome mechanical troubles that there is to-day. We are still more fortunate with respect to the cost of fuel than our foreign friends, and yet, our locomotives of modern design are in general, just as efficient in the use of fuel as theirs, and far more efficient as maximum freight movers per unit of time. This high cost of fuel, however, has made it of the utmost importance to devise some more efficient method of producing and utilizing steam for power purpose. This has been particularly true abroad. Probably the most outstanding developments over there has been the use quite recently of high pressures, going up to 840 pounds per square inch, and the use of turbine condensing engines with moderately high pressure. Other features now being tried are uniflow cylinders, improved valve gears, poppet valves, and out of this experimental work will undoubtedly come some one or more successful fuel saving systems that will not subtract from the general reliability of the locomotive and its fitness for continuous service, nor will it add materially to the maintenance cost. The ultimate possibilities of these experimental locomotives have not yet been proved and it will take some time before we can assure ourselves of the reliability and maintenance cost as against fuel economy. In this country we are reaching for higher pressure. We have built one locomotive having 350 pounds pressure for the Delaware & Hudson and are building another which will have 400 pounds pressure.

The one in service has shown very satisfactory fuel records and, so far, without any excessive maintenance cost. It is of the two cylinder cross compound type with water tube firebox. We must look to the very high pressure boiler as a source of economy in fuel, and undoubtedly great strides will be made in this direction in the near future. Our methods of steam utilization may come with it in order to obtain greater economy.

While we are always striving to better things, we need not be ashamed of coal records from existing steam locomotives showing better than two pounds per indicated horse power hour; of steam records of better than sixteen pounds per indicated horse power hour. These are the results of refinement in design, of improved material and better construction, and yet with all of this refinement we do not need to find excessive complications and high maintenance. We have freight locomotives to-day giving as high at 9,000 miles a month in regular service; passenger locomotives giving still more, and we can all feel proud of the performance of our movable power plants which show such excellent economy in the use of fuel coupled with reliability for continuous service.

The Present and Future of Locomotive Design

By A. G. Trumbull, Chief Mechanical Engineer, Erie Railroad

Entertaining, as I do, certain convictions regarding important features of design in the locomotive of today and in the early trend of development which these features may be expected to take, I will explain briefly my reasons for these views, in order that you may be better prepared to accept or reject them in accordance with the dictates of your own experience.

The increased cost of all commodities resulting from the draft of man power during the world war everywhere stimulated intensive studies of the processes of production. The continuing economic disturbances produced by unbalanced application of labor and the consequent relative high cost of basic commodities has made the elimination of waste a necessity in every direction, but nowhere has it been more important than in transportation, upon which not only depends the progress and development of the country, but the happiness and welfare of all its people. Then, too, attention has been focused upon the railroads because of conditions arising out of Federal control and the general impression created that

private management and operation were, in some degree, on trial. The marked efficiency and economy recently obtained have caused widespread comment and general commendation, and may be expected to stimulate further improvements in operation and in the development of the mechanical means essential thereto. Although there have been occasional references to the substitution of other means of power application, it is safe to say that, for the next generation at least, the reciprocating type of steam locomotive will continue to be the chief means through which power is converted to the requirements of transportation.

The trend of development of the locomotive has, naturally, been twofold. First, and most important, with respect to the boiler; and, second, and of lesser importance, with respect to the engine. I place the boiler first because the principles underlying steam application have long been better understood than have those of economical generation, especially as applied to locomotives. Indeed, we are today without the basic facts upon which to design with certainty a locomotive boiler to produce most economically the maximum evaporation under varying service demands with a minimum fuel consumption. In this respect the stationary steam generation plants have long been models of scientifically efficient mechanical precision.

The more recent examples of current locomotive design have featured a relatively larger grate area than has heretofore been the accepted practice, and this has naturally resulted in an increase in firebox volume, which impresses me as offering the greatest opportunity still available for the economical utilization of coal in steam production.

Combustion is a distillation and a chemical process, the former being characteristic of fuels having considerable volatile matter, as in the case of soft or bituminous coal. The process of combustion consists of effecting a combination of oxygen from the air with the carbon, sulphur and hydrogen in the fuel. This is true, regardless of the fuel used; that is: coal, oil, wood or lignite.

Those solid fuels having high percentages of volatile matter with which most of us are chiefly concerned, on being heated, give off the volatile portion in the form of a gas or, as is commonly the case, mixture of gas and fine particles of solid material. The solid residue remaining on the grate consists chiefly of fixed carbon, sulphur and varying amounts of substances that will not conbine with oxygen or, as we express it, "non-combustible." In order to secure combustion of the volatile gaseous portion of the fuel, it is necessary that it be mixed with a definite proportion of air heated to a high temperature; therefore, a definite furnace volume is required above the grates, which is the reason for the familiar difference in firebox construction between anthracite and bituminous coal burners.

All of the air required for the combustion of the volatile matter passes up through the fuel bed, and, as the rate of combustion per square foot of grate increases, the velocity of the air through the fuel bed must also increase with a consequent tendency to carry small particles of the solid combustible above the fuel bed. It is possible, under these circumstances, to secure complete combustion, both of the volatile and solid portions of the fuel; but, if the furnace volume is insufficient, the gas, consisting of volatile, combustible air and fine particles of solid fuel, may enter the flues, where the temperature is likely to be reduced below the point at which the necessary chemical union of the oxygen with other materials may take place, and substantial losses thus occur in combustion efficiency.

It will thus be observed that those coals whose particles are most coherent; that is, those of the coking variety, are less likely to be broken up by the air currents through the grates, and thus may be more satisfactorily burned at high rates of combustion.

It will be seen from these brief considerations that grate areas, furnace volume and air supply are essential factors in combustion. Moreover, in general, chemical processes are vitally influenced by the time element, those that are not hurried being likely to be most complete, or, as in the case of the firebox, if the volume is sufficient, and the grate area adequate, the velocity of the air and gases will be low enough to permit complete, or nearly complete, combustion with a maximum heat absorption or evaporation.

These principles have characterized the development of stationary boiler practice during the past few years, as will be observed from the accompanying table, which shows the principal relations between the horsepower, per cent. of normal horsepower developed, per cent. of furnace volume per pound of coal burned, over-all efficiency and other interesting factors indicating the influence of combustion volume upon boiler output. This table indicates that, since 1905, with a hand-fired boiler, the furnace volume per pound of coal fired has increased more than 4½ times with a stoker-fired boiler, and more than 7⅓ times with powdered fuel. The corresponding boiler ratings are 125, 275 and 300 per cent., respectively. It is of importance to note that this remarkable increase in capacity has been attained with an increase of more than 22 per cent. in evaporation per pound of coal having a fixed heating value. This very extraordinary development in steam generation would appear to indicate that there are yet undeveloped possibilities in locomotive boiler capacities to be attained through the use of large grate areas combined with as high a ratio of furnace volume to grate area as is consistent with limiting clearance dimensions.

TREND OF FURNACE DEVELOPMENT IN STATIONARY BOILER SERVICE, CENTRAL POWER PLANTS

Year	Method of Firing	Size of Boiler Units in General Use, h.p.	% of Furn. Vol. Per Pound of Coal Compared With 1905	% Rating Representing Good Practice	% Increase Over 1905	Lbs. of Coal Per Lb. of Water Evaporated	% Decrease Under 1905
1905....	Hand	450	100	125	...	.1227	...
1910....	Stoker	450	180.5	175	40	.1165	5
1915....	"	670	216	225	80	.1104	10
1920....	"	830	434	225	80	.1068	13
1925....	"	1450	455	275	120	.1003	18
1925.... Powd. Fuel	Pluv. Fuel	1450	736	300	140	.0974	21

Furnace Volumes in Power Plants.

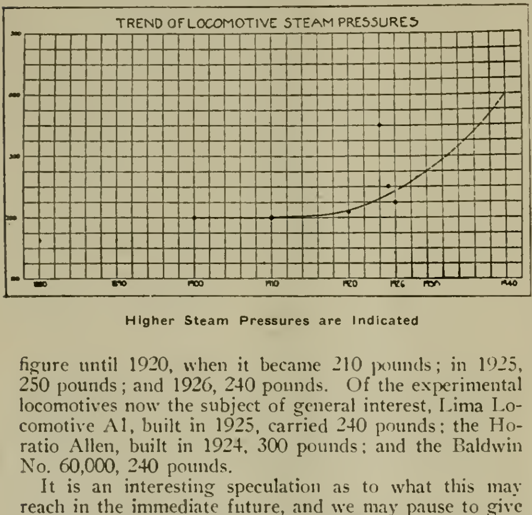
A locomotive of this description must, of necessity, have its firebox carried upon a trailing truck, thus materially increasing the non-adhesive weight and adding to the cost of maintenance and depreciation, as well as to the original cost. However, these disadvantages would be more than offset by increased boiler output, the importance of which may need no emphasis. In passing, however, it may be well to remark that, with a locomotive of given dimensions, the hauling capacity at any speed is dependent upon the steaming capacity of the boiler. Consequently, if the boiler can be proportioned to produce a greater volume of steam with a possibility of improved furnace economy, a locomotive of given proportions will either haul more cars, or it will haul the same number of cars at increased speed, either of which will increase the available ton-mile hours of the locomotive, and that means reduced transportation cost.

There has also recently been a significant movement in the direction of higher boiler pressures, even with boilers of the conventional type.

The possibility of substantially increased economy through higher boiler pressure is a fundamental fact, the improvement being due to differences in the temperature of the steam. We do not ordinarily consider that a steam

engine is essentially a means for the conversion of heat into mechanical force; but, in an analysis of economies resulting from the use of steam, it is necessary to proceed with heat units as a basis. Now, a definite number of heat units is required to evaporate a pound of water into steam, and this pound of steam will do a definite amount of work; but, if the amount of heat is increased, either more work can be done with the same weight of water, or the same work may be done with less water. The increase in efficiency is measured by the difference in the heat content of the steam at admission and the heat content at the exhaust after expansion has occurred in the cylinder. That being so, if the initial pressure is increased through the application of additional heat, a relative increase in efficiency must result. Notable examples of recent construction carry 240 to 250 pounds pressure, representing an approximate increase in economy of 8½ per cent. over a boiler carrying 200 pounds pressure. This economy is, of course, obtained in the cylinder, and it is somewhat reduced by the losses occurring in the boiler, due to the higher temperatures of the firebox, the shell and the smokebox gases.

In connection with the trend toward increased pressures, I have undertaken to show graphically the progress which has occurred since 1880. Reference to the chart indicates that, between 1880 and somewhere between 1890 and 1900, the boiler pressure of a representative number of locomotives purchased by prominent railroads remained stationary at about 160 pounds. Some time before 1900 this increased to 200 pounds, continuing at this



Higher Steam Pressures are Indicated

figure until 1920, when it became 210 pounds; in 1925, 250 pounds; and 1926, 240 pounds. Of the experimental locomotives now the subject of general interest, Lima Locomotive A1, built in 1925, carried 240 pounds; the Horatio Allen, built in 1924, 300 pounds; and the Baldwin No. 60,000, 240 pounds.

It is an interesting speculation as to what this may reach in the immediate future, and we may pause to give it a moment's consideration. By drawing a line through the points on the diagram, and extending this line in the direction that it naturally would take, it is possible to approximate the pressures that will be reached within the next ten or fifteen years if the present tendency continues. It will be seen that we may anticipate that, by 1935, we shall have locomotives quite generally carrying 325 to 350 pounds pressure. In view of the probable influence produced by the introduction of the water tube boiler, this does not appear to be an unreasonable conclusion. On the contrary, there are some forward-looking locomotive designers who predict that we shall ultimately reach pressures as high as 650 pounds, but I am too much handicapped by the limitation arising out of practical experience to share so venturesome an opinion. In fact, such pressures appear highly improbable because of considerations both theoretical and practical. While, as has been explained, there is an advantage to be gained through higher steam pressures than are now usually employed, the increased economy becomes progressively less as the pressure increases, and at very high pressures the saving cannot be realized through simple expansion. Then, too, the difficulties of maintenance that may be imagined with excessively high pressures, even with a well designed water tube boiler, are too great to warrant the conclusion that such pressures are of practical application.

It is unfortunate, perhaps, that our experience with compound locomotives antedated the present tendency to higher boiler pressures, because the difficulties in maintenances and the operation problems they introduced are likely to retard the reintroduction of the compound, notwithstanding its economical possibilities. The compound for general service was originally introduced mainly for the purpose of preventing cylinder condensation; but, with the successful development of the superheater, this advantage disappeared and with it the train of difficulties still fresh of memory. However, the gain through a greater range in initial and exhaust pressures cannot be realized through the higher boiler pressures without using the compound principle, because in a single cylinder at long cut-offs it is impossible to expand the steam down to the required exhaust pressure. This fact accounts for the use of the cross-compound design of the Horatio Allen. In the case of the Baldwin engine, however, the compound feature was probably introduced to secure the advantage of the three cylinder arrangement and at the same time obtain the economy resulting from decreased heat losses in the cylinder walls produced by expanding the steam in two stages; that is, in a high pressure and two low pressure cylinders.

The next factor for consideration in connection with high steam pressures is the boiler. I think there would be great hesitancy on the part of motive power officers to build the present type of boiler to carry much in excess of 250 pounds pressure, even through the introduction of steel staybolts, because of their greater strength and ductility, promises to reduce failures. But, even with this advantage, the maintenance cost of flat-stayed firebox surfaces, staybolts, tubes and tube sheets of the fire tube boiler is certain to hasten the use of the water tube boiler as soon as it can be said to have passed the experimental stage.

In addition to the reduced cost of maintenance of this type of boiler, which has been said to approximte 50 per cent., there has been great expectancy of relatively increased steaming capacity. The use in firebox construction of tubes and cylindrical drums, in place of flat stayed surfaces, makes it possible to reduce the thickness of the material, and this ought to favor heat transfer and consequently increase the evaporation per square foot of heating surface. Unfortunately, there are no capacity tests of this type of boiler available; those which have been made were on relatively the same basis of boiler demand, and show no increase in evaporation per unit of heating surface over boilers of the usual construction.

In addition to the anticipated gain through increased heat transfer, there is an undeniable advantage in improved circulation and also in the greater firebox volume attainable within the prescribed clearance limitations. These factors should produce a marked influence upon the capacity and serviceability of the boiler.

Now, with a boiler of any type designed to afford a maximum firebox volume, a considerable part of the weight will be transferred from the drivers at the expense of adhesion, and right here a very important difference of opinion develops between locomotive designers,

but I believe this will disappear with the completion of the investigation of the service rendered and the economy developed by the experimental locomotives now in service. The situation is very well illustrated on the chart of comparisons between the Lima and Baldwin engines and the Horatio Allen. It will be observed that, in the case of the Lima engine, the ratio of adhesion that is, the calculated ratio of weight on drivers to main cylinder tractive power is but 3.58, which is admittedly too low unless some compensating feature is introduced. This problem is met in two ways: First, by the application of a booster to the trailer truck; and, second, by the use of the limited compensated cutoff feature. Both aid materially in the production of maximum hauling capacity at slow speeds and the limited cutoff also greatly increases the cylinder horsepower at speeds.

Comparative Proportions Recent Experimental and Other Locomotives

Engine	Type	Boiler Press	Tract. Power	Evap. Heating Surface, Sq. Ft.	Grate Area Sq. Ft.	Ratio Heating Surf. to Grate Area	Firebox Volume Cu. Ft.	Ratio Firebox Volume to Grate Area	Factor of Adhesion
Horatio Allen	0-8-0 Comp.	350	70300	3200	71.4	44.81	575	8.05	3.25-S 4.25-C
Baldwin 60,000	4-10-2 Comp.	350	82500	5192	82.56	62.89	735	8.9	4.10-C
Lima No. 1	2-8-4 Sim.	240	69400	5110	100	51.1	515	5.15	3.58
N.Y.C. 8000	2-8-2 Sim.	210	66700	3676	70	52.5	372	5.3	3.72
Penna. I-IS	2-10-0 Sim.	250	90000	3944	70	56.3	385	5.5	3.8

Data From Some Recent Designs.

It should be observed that, with a fixed cutoff as short as 50 per cent., when the usual type of valve design is employed, at starting, or at extremely slow speeds, the main steam ports will not open, and to meet this condition additional or so-called compensating ports have been introduced, these ports consisting of small slots in the valve chamber bushings, their effect being to slightly increase the cutoff at slow speeds. The value has long travel, consequently at high speeds the rate of travel is high enough to uncover the main steam port before enough steam can escape through the compensation ports to materially influence the steam distribution and the effect of these ports therefore practically disappears.

It may be observed in passing that the cutoff may be fixed without the use of compensation ports, but not at as high a figure as 50 per cent. With the ordinary type of valve gears, a fixed cutoff of 70 to 75 per cent can be secured by increasing the steam lap of the valve and by changing the ratio of the lap and lead lever to correspond with the increase valve lap. Incidentally also, this measure affords a desirable means of improvement in existing locomotives, especially as it can be so readily accomplished.

The next feature of interest and value in locomotive operation contributing to increased efficiency and economy is cutoff control by means of back pressure which may be either manual or automatic. It has long been known that for each class of locomotive—and a distinction is here made between type and class—there is a point of cutoff for each speed that will produce a maximum hauling capacity. An attempt was made some years ago to apply this principle in practice by furnishing a card to enginemen on which the necessary information was given in table form but the plan failed of general adoption because it imposed too great a burden upon an already very busy engineman. The use of back pressure as a means of establishing maximum hauling capacity is, however, of comparatively recent application.

Other conditions being the same, back pressure varies directly with the admission pressure, cutoff and speed and for each class of locomotive there is a definite back pressure which if maintained at a constant figure will produce the maximum mean effective pressure with a cutoff proportional to the speed of operation. This back pressure is easy of determination by experiment and the locomotive may then be operated accordingly with every assurance that it is producing maximum power. Of course, the back pressure constant is correct only for the boiler pressure at which it is established which should be the normal one. The most general method of regulation is manual corresponding to the indications of a special back pressure gauge, but a mechanical control has been devised which if successfully developed will insure the nicety of regulation difficult of attainment where dependence must be placed upon the necessary constant manual manipulation.

From the foregoing considerations it seems reasonable to conclude that the high duty locomotive of today should have the following characteristics:

A boiler of the conventional type with considerably larger firebox volume than has been commonly used.

A steam pressure of 225 to 250 pounds.

A fixed minimum cutoff.

Means of increasing the hauling capacity at starting when it can be advantageously employed, which would naturally take the form of a booster applied where advantage may be taken of the maximum available non-adhesive weight.

Means to permit operation of the locomotive with a pre-determined back pressure.

As to the future it would appear that logical development may be expected to proceed along the following lines:

The extended use of water tube boilers still utilizing the large firebox volume, and in the early stages, employing steam pressures up to 250 pounds per square inch.

Increase in steam pressures up to 350 pounds per square inch as experience may dictate.

An extension of the use of compound engines to secure the advantage of the higher pressures, such engines being of the three and four cylinder type.

The Designer Must Have Courage

By W. L. BEAN, Mechanical Manager, New York, New Haven & Hartford Railroad

Former consideration of steam locomotive capacity was almost exclusively on a tractive effort basis, especially by operating officers, and although starting effort should be ample, a locomotive with high starting capacity, low sustained boiler capacity, and large cylinders shows up poorly on a speed tractive effort curve or on a speed draw bar horse power curve. In the days of drag freight operation, the considerations were tractive effort and gross ton, but now they are draw bar horse power and gross ton miles per train hour.

To produce capacity and economy under such requirements, additions and refinements utilized with marked results in recent years are those which in principle and practice, particularly in steam production, have contrib-

uted largely to advantageous operation of central station.

Crowded clearances and restrictive weights tax heavily the skill and courage of the locomotive designer in successfully adapting stokers, water tube fireboxes, feedwater heaters, superheaters and front end throttles to a large locomotive, but great progress has been made.

In principle and practice superheating is accepted by managements even to the rebuilding of many old locomotives, so that they have increased capacity and economy. Through experience and further study the designer can utilize improvements in superheating which produce decided further advantages, especially where sustained horse power at the faster speeds is requisite.

Augmented superheating surfaces with increased cross section area of both gas and steam passages produce surprising results in increased maximum horse power, as well as greater horse power, at faster speeds. High evaporative rates in large locomotives, with relatively short distances between water surface and dry pipe opening, produce wet steam. Hence the need for large superheater areas to produce higher average steam temperatures, as well as the other advantages. Two Pacific-type locomotives equipped recently with superheaters and feedwater heaters were improved twenty per cent. in horsepower output.

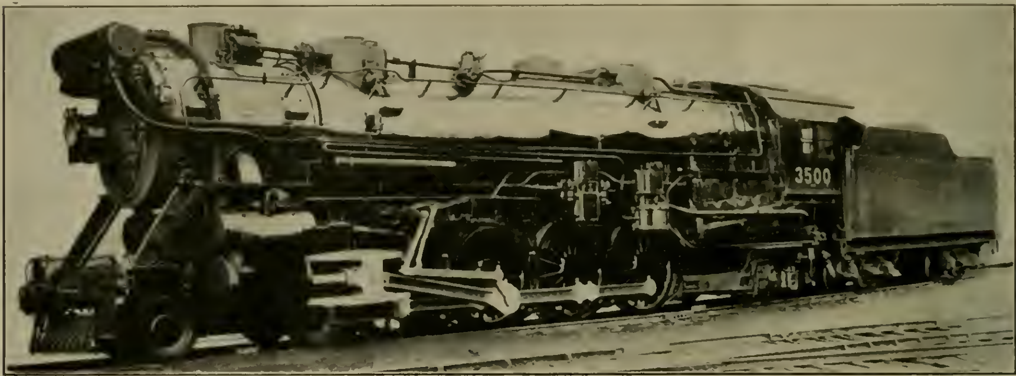
Feed-water heating on locomotive fills an important gap in the heat cycle and yields large returns proportionate to the investment and maintenance cost, both through fuel economy and increased boiler capacity. What engineer would consider designing a stationary or marine power plant and not use feed-water heaters? Less foreign matter enters the boiler, and tank capacity is proportionately increased.

Agreement as to application of stokers on heavy power is general, and devices currently offered are well worked out as to design and are of ample capacity and dependable.

Integral steel castings replacing fabricated constructions yield good returns. Every bolt, nut, key, rivet, pin, or other separate member eliminated means trouble and expense avoided. The availability of power is increased hazard of accidents reduced, and length of total life of members increased. Comparison of the life of tender frame alone is striking.

Unquestionably the next great line of development will be the use of higher steam pressures through water-tube construction. Locomotive practice trails badly the central station, and even the steamship in this respect. Inspection of steam temperature data shows clearly the advantages of high pressures. Radical design changes not only of the firebox, but of construction for absorption of heat by convection, are required for handling the high boiler pressures. Fire-box construction of tubes, drums and hollow foundation ring already service and tested permit of moderate increases in pressure with present boiler barrel constructions, but full utilization means general redesign, and hence probably considerable experimentation.

It is recalled that twenty to thirty-five years ago pressures of 220 to 230 pounds were general with compounding. When the superheater became available and return to single expension was made, motive power men were glad enough to lower boiler pressures to 180 to 200 pounds because of maintenance problems with stay bolted construction.



Locomotive No. 3500 of the New York, New Haven & Hartford Railroad Equipped with the McClellon Water Tube Boiler

Now the trend of pressure is very properly headed the other way, and, while working out the problems of design, including compounding with all its difficulties, using, probably, 600 to 1,800 pounds pressure, we can avail ourselves quickly of considerable advantage through using water-tube fireboxes which are already being used with pressures up to 350 pounds.

One carrier operates two Mikados of 45,000 pounds tractive effort equipped with water-tube fireboxes and with 200 pounds pressure, built in 1916, and giving good results; it has another, a Mountain type of 250 pounds pressure, built in 1924, and producing splendid results. Recently, it placed in service ten large Mountain type locomotives, three of which have three cylinders, and all have water-tube fireboxes and carry 265 pounds pressure. Further purchases of new power will unquestionably be of water-tube construction. These latest ten engines are doing excellent work, particularly those with three cylinders.

A designer of high-powered engines will include among other important factors the following:

Higher boiler pressure.

Improved type of superheater, including ample and properly proportioned evaporating and superheating areas.

Grate area and grate design.

Fire-box volume.

Special devices for promoting the extent and distribution of circulation of water.

Steam storage space (which is small at best).

Ample water surface for steam release.

Outside dry pipe and front-end throttle.

Use of superheated steam in stoker engine, air compressor, feed pump and other auxiliaries.

Ample cross-section areas for steam and gas passage.
Limited cut off.
Booster.
Back pressure gauge.
Pyrometer.
Special care to eliminate air leaks into smoke box.
Tenders of maximum water and coal capacities.

The last decade has seen remarkable progress in locomotive design leading to new and surprising records of a performance almost daily, and, with our impetus and continued application of the skill and endeavors of engineers of the locomotive builders, specialty companies and of railroads, one can not safely venture a prediction of accomplishments to follow.

The road foreman of engines is a very important factor in capitalizing to the full the opportunities at his command. Continued instruction of engine men, explanation, demonstration and encouragement in the full and correct use of improved devices are indispensable. The road foreman, by keeping himself up to date, will enhance his value and get keen satisfaction from full accomplishment.

Improving the Steam Locomotive

By JOHN E. MUHLFELD, Consulting Engineer

Considering the term "locomotive" broadly, as relating to any kind of mobile machine used for transportation on land, my observations in several countries during the past few months indicate that the steam locomotive, after about a century of commerical service, is still the premier self-contained motive power for the safe, expeditious and economical movement of passengers for relatively long distances, and of tonnage freight for both long and short hauls, and that it also provides the most comfortable means for traveling. I predict that, with the inauguration of the many possible constructive and operative improvements, it will maintain this position for several generations to come.

We have, in our most modern conventional types of steam locomotives, a machine that, at its best, will produce from seven to eight per cent. thermal efficiency in terms of the best value in the fuel fired. In average road service this percentage will be reduced to from four to six per cent., and is being obtained in the basic design by the use of from 200 to 250 pounds boiler pressure in combination with an average amount of superheat in two to four single expansion cylinders, or in duplex multiple expansion types of cylinders as used in Mallet type articulated locomotives. Auxiliary devices, such as brick arches, thermic syphons, exhaust steam feed-water heaters and various other accessories, are now being quite extensively applied to both existing and new locomotives to supplement the basic design for the purpose of increasing the efficiency and economy.

In order to double the prevailing thermal efficiency, and bring it to about fifteen per cent., I will offer the following suggestions for your serious consideration:

1. Steam of from 400 to 800 pounds boiler pressure superheated so that the total temperature will not exceed 750 degrees Fahrenheit.
2. Multiple or a higher rate of expansion of the higher pressure superheated steam.
3. Better distribution and utilization of the steam in the cylinders.
4. Reduction in cylinder back pressure.
5. Reduction in loss of superheat from stack.
6. Reduction in loss of steam pressure between boiler and cylinders.
7. Reduction in moisture contents is saturated steam.
8. Improved circulation of water in the boiler.
9. Greater volume of steam space in the boiler.
10. Improved combustion of fuel.
11. Greater utilization of products of combustion of evaporation and superheating.
12. Feed-water heating with both waste steam and gases.
13. Shorter rigid wheel base.
14. Greater utilization of engine and tender total weight as adhesive weight for starting acceleration and running, and to negotiate ruling grades.
15. Reduction in dynamic augment in preference to reduction in axle loading.
16. Greater accessibility of boiler and machinery parts.
17. Reduction in number of detail parts and accessories subject to wear, failure and breakage.
18. Reduction in smoke, cinders and noise.
19. Automatic force feed lubricators for valves, cylinders, stokers, air pump, and feed-water heater.

The natural question is, "How can this all be done and how much is it going to cost?" From my recent observations in Europe, and what we have learned from the "Horatio Allen" 350 pounds pressure, cross-compound locomotive, in road freight service on the Delaware & Hudson during the past two years, and which is being supplemented by the "John B. Jervis" locomotive now under construction, which will carry 400 pounds boiler pressure, it is my opinion that these results can be obtained at a reasonable investment cost along the following lines:

1. Combination water and fire flue and tube boiler which will eliminate existing conventional crown and side sheet type of firebox and substantially increase the firebox evaporation surface.
2. Improved fire-flue superheater which will substantially reduce existing resistance to flow of steam through same.
3. Combination of one or two each main high and low pressure cylinders, all placed outside of the engine frames.
4. Poppet valves and improved valve gear, all disposed outside of frames.
5. Radical change in exhaust nozzle and smoke-box draft appliances, including an automatic variable nozzle.
6. Removal of dry pipe, throttle valve and superheater header to outside of boiler and smoke-box.
7. Enlarged and unobstructed passages throughout the boiler, particularly at furnace end, to provide free circulation and ebullition and increased saturated steam space.
8. Self-contained equipment on engine and tender to provide for preparation and burning of either solid or liquid fuels in suspension.
9. Production of a greater percentage of saturated steam at furnace end of boiler.
10. Better distribution of flow of products of combustion around and through evaporation surfaces and as between evaporation and superheating surfaces.
11. Combination waste steam and flue gas feed-water heaters.
12. Reduced total weight of engine and driving axle load per pound of tractive power.
13. Elimination of all unnecessary leading and trailing wheels.
14. Use of high elastic limit steel castings or forgings

to reduce unsprung weight in driving axles, wheel centers, and main and side rods, as well as in other revolving and reciprocating parts.

15. Make basic design of boiler and machinery, such as will provide maximum power, efficiency and economy without use of unnecessary dead weight and complication in accessory equipment.

16. Adequate counterbalance in each driving wheel and keep centers of gravity of planes of revolving and reciprocating parts as close as possible to the planes in which the counterweights revolve.

The foregoing seems like a large order, but representative European and American railway engineers have agreed that such changes can and should be made in the future American steam locomotive which will have a life of from forty to many more years and which will bring its thermal efficiency up to that of the self-contained Diesel or internal combustion engine and far beyond that of the electric locomotive, at much less investment, maintenance and operating cost per unit of power developed.

It is well to remember, in this comparision, that the governing factors in producting efficient and economical hauling capacity in the steam locomotive is to overcome heat reduction, and in the electric locomotive to prevent heat rise. Also that electric motor equipment has already reached a high state of efficiency, whereas the possibilities of improving the efficiency of steam generation and utilization are almost unlimited.

When the first Mallet locomotive was put into use in the United States, it was not received very enthusiastically. In fact, my great delight, when at the St. Louis Exposition in 1904, was to go to the space where this locomotive was exhibited and listen to the profanity and comments of the "eagle-eyes" and other railway men when they were giving it the "once over." This locomotive, besides being a 200 per cent. engine, was designed with 235 pounds boiler pressure, 21-foot boiler tubes, large grate area and firebox, Walschaerts valve gear, automatic cross-compound type cylinders, high pressure cylinder piston valves, power reverse gear and many other "monstrosities." I realize that the majority of you gentlemen do not favor the Mallet. There are many of them that I do not like as when we got out this first sample, which, after 22 years' service, is still in use on the Baltimore & Ohio. It has done more to increase the average freight train load, reduce fuel consumption, and keep down the freight rates, than any other piece of motive power in use on heavy grade lines, and the articulated feature has been copied by the electric locomotive, passenger car, automobile, and many other designers. You are also aware of how the outside valve gear, power reverse gear, long boiler tubes, large firebox and grate areas, and even the 235 pounds steam pressure have since been introduced.

With respect to the "Horatio Allen" locomotive, which has been in regular road freight service on the Delaware & Hudson between Oneonta and Mechanicsville, N. Y., during the past two years, for experimental and development purposes, sufficient data has already been presented and published for your information in the technical journals.

The outstanding features of the "Horatio Allen" are its reserve power; starting, acceleration, and hauling capacity; adhesion to the rail, speed on ruling pulls; ease of pumping boiler, maintenance of constant water level in boiler; dryness of saturated steam as delivered to superheater; less noise from exhaust steam; and low fuel consumption.

This locomotive has now made about 54,000 miles as a single crewed and a pooled engine, and nothing has developed in its road service or terminal handling that necessitates its being given other than the same attention received by other steam locomotives. The reason for its not having made more mileage is on account of the repeated minor changes made in connection with the experimental and test work undergoing which relates to high pressure and power, steam distribution, multiple expansion and like factors. The boiler and the 350 pounds steam pressure have given remarkable results, and another more simplified design is now under construction, which will make use of 400 pounds boiler pressure and will be named the "John B. Jervis." This locomotive will be ready for service probably during October or November of this year.

Since the first locomotive testing plant was installed at Purdue University, when I was a student there, in 1891, several others have been built, those now in existence being notably at Purdue, where the greatest amount of work has been done, the Pennsylvania at Altoona, and at the University of Illinois.

Important features of the modern steam high pressure locomotive boiler are combustion, maximum utilization of radiant heat, high rate of heat transfer, efficient convection, size and weight to meet clearance in track and bridge limitations, use of highly heated, preheated air, use of powdered fuel and reduction in the stack gases to about 400 degrees Fahrenheit.

We are sorely in need of definite scientific information relating to steam locomotive combustion, heat absorption in boiler, distribution and use of steam, reduction of cylinder back pressure, superheat, feed heating by waste steam and gases, boiler efficiency in relation to production and exhausting of steam and to intermittency of exhausts, relation of grate area to fire-box volume and heating surface and to fire flue and tube heat surface, relation of fire flue to fire tube gas areas and of superheater element to fire flue areas, compounding, insulation, draft, combustion and cinder losses, furnace and flue gas temperatures, dynamic augment, and many other important factors in railway operation and maintenance. For example, water converts directly into steam, and at a temperature of about 700 degrees Fahrenheit when under a pressure of about 3,000 pounds, and steel will stand up under heavy pressures at a temperature of about 900 degrees Fahrenheit. We can, therefore, see the possibilities as regards further developments in the direction of steam temperatures and pressures.

In recently installed, pulverized fuel burning central power stations, the heat in the fuel that is actually absorbed by the boiler and superheater will average 85 per cent., and by the boiler, superheater and economizer 91 per cent. This performance is obtained with coal having about 12,600 B. T. U., over 2 per cent. moisture, 35 per cent. volatile, 51 per cent. fixed carbon, and 11 per cent. ash, and the CO_2 in the stack gases averages 15 per cent. In steam locomotive performance, with the best hand firing, we get a combined boiler and superheater performance of about 75 per cent., and the average will run about 65 per cent.

The foregoing is cited to show how much still remains to be done in steam locomotive boiler development and operation.

The American Railway Association, mechanical division, should be provided with a centrally located, modern locomotive and car testing plant which can be used by all member railroads and devoted to the scientific and unbiased research and study of the complete locomotives and cars, and of the detailed equipment, material and special appliances relating thereto. In this way correct designs and materials and the fundamental and the scientific laws governing locomotive and car operation and efficiency could be determined in a constructive, practical

and economical manner. Then, by combining this information with that which can be obtained in the field with dynamometer and track inspection cars on long runs and heavy grades, we can secure the fullest measure of result with respect to the drawbar pull and train resistance factors, in addition to the combustion and steam data which can be obtained both in the field and in the test plant.

Such equipment and procedure would enable us to investigate the possible greater use of raw or heat and oil treated lignite, high ash and sulphur with low fusing point ash coals and other solid fuels that must replace oil and the higher grade and cost of coals, as these natural resources are depleted or diverted to other more important uses.

Provided with such facilities and with unbiased facts as to the actual results of steam locomotive road operation, I have no hesitancy in saying that we could readily double the existing steam locomotive thermal efficiency and otherwise reduce the future fuel, water and other supply and transportation costs to the extent of hundreds of millions of dollars annually, with a relatively small proportionate increase in the investment cost of the steam locomotives themselves.

The Locomotive in Operation

By A. R. AYRES, Assistant General Manager, N. Y. C. & St. L. R. R.

From an operating standpoint, a locomotive must meet several conditions:—

It must handle the required tonnage, or number of cars at the necessary speed.

It must do this with the minimum consumption of coal and water.

The first cost and cost of maintenance must be reasonable.

It must be capable of running long distances between terminal repairs.

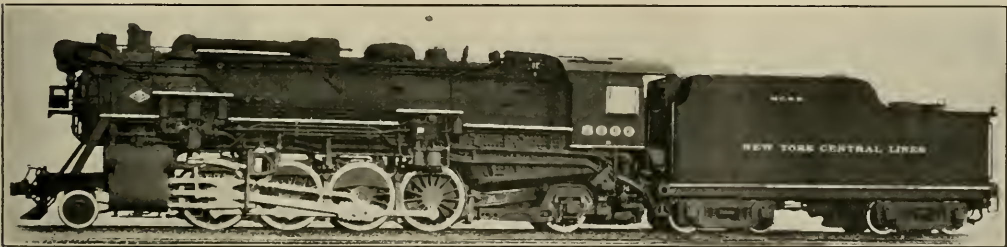
It should be capable of performing service the maximum number of hours, in order that the number of locomotives required and therefore the fixed charges on the capital investment, may be the minimum.

Freight of all kinds is moving to-day at higher speeds than ever before; miles per car day increased from 25.1 in 1920 to 28.3 in 1925 or 10 per cent in five years, and we may expect it to keep on increasing because fast movement of freight is saving shippers large amounts of money and is doing much to stabilize industrial conditions. In order that operating costs may be reduced this freight must be handled in large train units. These things require a locomotive that will develop great power at high speed. How well the builders and designers are meeting these conditions is shown by a comparison of a recent Mikado with one built in 1913; the later engine has only 17 per cent more total weight, but is about 40 per cent stronger at the start, 40 per cent at 20 miles per hour, 60 per cent at 30 miles per hour and develops 60 per cent more maximum cylinder horse power. It will do nearly 60 per cent more work per pound of coal than the early design.

This progress has been accomplished by careful attention to locomotive design and continuous effort to burn fuel more efficiently, to use steam more efficiently, and to waste less of the exhaust steam and gases of combustion out of the stack. These efforts have given us superheater, two-cylinder limited cut-off and three-cylinder locomotives, stokers, syphons, various form of feedwater heating apparatus, special forms of grates, high pressure boiler including several forms of water tube firebox, and many other features with which you are familiar in detail.

These added features are very much worth while and are accomplishing remarkable results, but they have materially increased the amount of inspection and repair time and labor required at terminals.

In order that the full saving of these appliances should be realized and not dissipated in repair costs and loss of serviceable engine hours, it is highly essential that they should make the same milage between general repairs that the main locomotive does, and that they should require comparatively little inspection and maintenance in the meantime.



Locomotive No. 8000 of the New York Central Built by Lima Locomotive Works

This is one of the most important considerations in connection with the modern locomotive; locomotive designers and specialty manufactures with their expert service men unquestionably are giving it much thought and effort, and there is no reason to doubt that they will accomplish the desired results. The extent to which automobile designers have met and solved the same problems is one of the reasons for the success of the modern automobile.

Locomotives, to-day, not only have a great many devices for increasing fuel capacity and economy but, as you know, beginning many years ago with valve gear, a great many details of construction have been improved mechanically, so that the locomotive today will run about twice as far between general repairs at it would twenty years ago, and the liability of failure is very much less.

Machinery parts, including lightened and strengthened by better design, and the use of high quality steels, and the weight saved in this way has been put into better boilers and fuel saving devices. New features are being

developed constantly, and by continued attention to these things we can increase the capacity of the locomotive, increase the mileage between shoppings, and cut down the amount of attention required in the meantime. Assuming that the engine is well designed and built and maintained, all of which is fairly well done to-day, there remains the problem of using it to the best advantage. This is one of the greatest of all and one in which you are vitally interested; it is receiving serious thought and attention from both transportation and mechanical departments.

Traveling engineers and traveling firemen may play a most important part in developing the loading and operating of modern high powered locomotives to take full advantage of their capacity and economy. To do this, they themselves must have expert knowledge of the capacity of the machine, and must follow up the performance of the various special devices, and instruct enginemen how to use them to the best advantage. In doing this they may, of course, receive much benefit from the locomotive and specialty service men who are experts in their particular lines.

We spend considerable money for devices that will save 10 to 25 per cent of fuel but actual tests have demonstrated that poor firing or working the engine with wrong throttle and cutoff may easily waste from 10 to 15 per cent of the fuel. Light loading of trains is perhaps even more wasteful.

Four items that vitally affect the capacity and economy of the steam locomotive are cutoff, throttle opening, back pressure and draft.

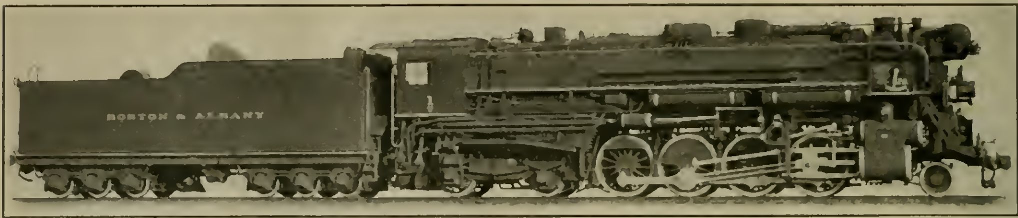
If a steam locomotive is worked beyond 35 to 40 per cent cutoff, the consumption of steam increases far beyond the proportionate increase in power; in other words, the engine becomes wasteful of steam.

Economies produced by two-cylinder limited cutoff engines and three-cylinder engines which are brought about partly, at least, by working steam at considerably shorter cutoff than ordinary practice, have caused us to run a number of tests to determine whether our locomotives are being operated at or beyond the point of economical cutoff. During these tests the engines were operated under full throttle practically all of the time.

On some of these runs, it was found that the cutoff was over 40 per cent about seven-eighths of the time, and on one run, which was a fast heavy tonnage train, the engine was worked over 50 per cent cutoff 89 per cent of the time; these engines were U. S. R. A. Mikados equipped with feedwater heaters and boosters. To carry the tests further, the cylinder diameter on one engine was increased from 26 to 27½ inches, and the maximum cutoff with reverse lever in the corner reduced from 90 to 75 per cent.

Handling trains of practically the same weight and speed as another engine of the same class the modified engine was over 40 per cent cutoff only 39 to 43 per cent of the time, compared with 86 to 88 per cent of the time for the standard engine, and the modified engine showed from 3 to 9 per cent economy in fuel and about the same in water; the saving was, of course, greater on heavier trains. Much remains to be accomplished in developing means for producing the necessary draft on a locomotive without so much sacrifice of power due to back pressure. The importance of back pressure is, of course recognized, but may be emphasized by the statement that one pound of back pressure on a locomotive with 26 by 30 inch cylinders and 63 inch drivers at 35 miles an hour is equivalent to about 30 horse power.

Sometime ago two Mikados were equipped with a device for automatically controlling cutoff according to back pressure, and these engines demonstrated that where maximum power is required there is considerable gain in power as well as economy by working with full throttle and with cutoff adjusted to keep the back pressure within reasonable limits. These limits will, of course, vary according to the type of engine and kind of fuel. Since that time, a number of locomotives have been equipped with back pressure gauge, and the enginemen seem to be glad to have such gauges on their engines, because the modern locomotive is so large that it is difficult for the engineer to operate it to the best advantage when relying only on his judgment assisted by the sound of the engine.



Boston & Albany Locomotive A1 Built by Lima Locomotive Works

Feedwater heating devices in operation will reduce back pressure from 2 to 4 pounds and on engines with large grates, automatic stokers, by carrying a thin, even fire make it possible to get the maximum boiler capacity with less draft and consequently less back pressure than would be needed with heavy fires.

On large engines, the plain round exhaust nozzle does not appear to give as much draft per pound of back pressure as some form of nozzle which breaks up the exhaust jet and in this way provides more entraining surface for the front end gases.

This is a subject of first importance in connection with locomotive operation today. To show how far it can be carried it may be stated that engines which formerly were operated with 5¾-inch plain round nozzle are now in successful operation with special designed nozzles having an area equivalent to 6½-inch plain, round nozzle, resulting in considerable increase in power, without any sacrifice of steaming qualities.

On one division where the size and type of freight power has been unchanged for four years, except that some of the later engines are equipped with boosters and feedwater heaters, the average tonnage per freight train in the direction of heavy traffic has been increased 360 tons with an increase in speed of about three-fourths miles an hour. This figure is quoted to show what can be done partly by application of betterments and partly by attention to train loading and best methods of operating the locomotives.

Many notable examples of long engine runs on freight trains, as well as passenger trains, have been published

in recent months. The modern locomotive is entirely capable of running several hundred miles on either passenger or freight trains without repairs, and the advantages of this practice are so many that threre seems to be no doubt that it has come to stay, not only for oil-burners but also for coal-burners.

Among the advantages are, saving of fuel, otherwise wasted at terminals, saving in cost of terminal handling, better maintenance, more serviceable engine hours, and the general speeding up of freight train operation through the elimination of most of the delays waiting for power, and the consequent incentive to the transportation department to make up the trains and handle the terminal yard work so as to take full advantage of the through runs.

As far as maintenance is concerned, the long runs force good maintenance, and at the same time make it easier, because long runs generally carry with them longer layover periods which afford plenty of time to do the necessary work on the engine, and this time is not always available on short runs with quick turns.

ternal combustion engine has a lower fuel cost than the steam locomotive and the electric locomotive is apparently somewhat cheaper to maintain, although somewhat restricted in its field of operation, on account of requiring trolley wires or third rail. The steam locomotive, however, still holds the great advantage of much lower first cost, and is making great strides in fuel economy and starting power.

No doubt all three of these systems will continue to develop rapidly according to the demands of the service in which they operate.

The success of the modern locomotive has depended very much upon its acceptance and efficient handling by the enginemen who come under your supervision.

We are proud of the way in which our enginemen have accepted these appliances and have worked to get the most out of them; they appear to take pride in the accomplishment of the machine which they operate. I believe this is a general characteristic of locomotive enginemen.

Three-Cylinder Compound Locomotive Built by the Baldwin Locomotive Works

The great number of special devices on locomotives today has brought an enormous amount of piping and valves, so that railroads and builders are giving much thought to the problem of simplifying these things and at the same time making the engine more convenient and comfortable to operate. It is surprising how much can be accomplished by a little study along these lines.

One feature of the modern locomotive that is justly receiving much attention to-day is the proper amount of fuel and water to be carried on the tank. On heavy freight trains, delays due to stopping for any cause must be offset by costly reductions in tonnage. It is worth a great deal of consideration on any railroad to determine how much expenditure is justified in order to liminate or reduce stops for fuel and water.

Possible Future Developments

If a satisfactory design of condensing steam locomotive can be worked out, not the least of its advantages will be the elimination of all stops from water on the road, and delays for boiler washing at terminals, in addition to saving of fuel and boiler maintenance expense.

Some progress has been made with locomotives of this type in Europe but not much in this country on account of cost and the large size of locomotive involved.

The use of much higher boiler pressures with some form of water tube boiler construction appears to offer one of the most attractive fields for radical changes in steam locomotive design in the near future.

Discussion of the locomotive to-day would be incomplete without reference to electric and internal combustion locomotives. Both of these systems have the advantage of very high starting power and more serviceable hours per locomotive per day. In addition, the in-

Locomotive Buying Takes a New Turn

On September 1 the Class I railroads of the United States had 533 locomotives on order and were building 67 in their own shops, a total of 600 locomotives.

Of these, 267 were designed for passenger service; 225 for freight service; and 108 for switching service.

These figures indicate that at some time within the next six months the railroads will be installing more new passenger locomotives in service than freight locomotives.

That this will represent a substantial increase in the provision being made for passenger service may be seen from the installations and retirements for August of the current year. Forty-seven new passenger locomotives were installed and 49 retired. Seventy-seven new freight locomotives were installed and 143 retired. Six passenger locomotives and six freight locomotives had their pressures—and hence their power—increased.

Most of the earning power of the railroad industry is derived from its freight service. Hence, during the past six years the railroads have had to concentrate their investment on new cars and locomotives for freight service. Thus in the past four years, from January 1, 1922, to January 1, 1926, the railroads bought and installed in service 6,006 freight locomotives, 1,766 switch locomotives, and 1,632 passenger locomotives.

Now that the freight service has been tremendously improved and the earning power of the railroad industry increased to a considerable extent, the railroads are seizing the first favorable opportunity to invest in new motive power on a substantial scale for the improvement of their passenger service. This same movement is being reflected in increased orders for new all-steel passenger-train cars.

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Murder on the Rails vs. Murdering the Truth

In the September issue of Railway and Locomotive Engineering appeared an editorial in which we widely differed, and quite sharply criticized an article in current issue of the "North American Review" entitled, "Murder On the Rails," anonymously signed "Engineer."

The author of the article in question, both by omission and commission strayed so far from the well known facts essential to a truthful presentation of the subject, as to raise serious doubts as to the sincerity of his purpose.

In fact we felt then, and are now strongly impressed with the belief that such glaring misrepresentations might better be considered as qualifications for membership in the Ananias Club, rather than any claim on the engineering profession.

The American Railway Association could not of course remain silent on a matter of such vital importance to the railways and the traveling public, and we are glad to present elsewhere in this issue the very able and complete reply made by W. J. Harahan, President of the Chesapeake & Ohio Railway, and chairman of the American Railway Association Committee on Block Signals and Automatic Train Control.

Mr. Harahan's complete refutation of the unwarranted, joint indictment, against officers and experts of our railways, and certain government officers, should not only make it clear to all fair minded people that railway officers as a whole are not lax, indifferent or opposed to providing all possible protection to both passengers and employees, but are in full sympathy with and actually incurring great expense for the development and installations of such devices as engineering skill, thorough practical test, and sound business judgment have found to be acceptable.

Both railway and government officers, also neutral experts, who have to do with the problem of safety in general or of signals and train control in particular, well know that the matter has not been neglected or opposed by the railways as charged by the author of "Murder On the Rails." Through gross misrepresentation, however, the author has come dangerously near, if not actually Murdering the Truth.

Rates Secondary to Good Service

Adequate railroad service and a fair return are more important to business than railroad rates, according to the opinion of the Transportation Committee of the National Association of Manufacturers.

An analysis of railroad earnings for the period since Federal control shows that notwithstanding the remarkable improvements effected by them in efficiency, in economy and in actual performance, yet their returns are still substantially below a fair return on their property investment. The difference between the railroads operating net income and the amount equal to the fair return contemplated by the Transportation Act is approximately $2,064,000,000. This represents the amount by which the railroads have failed to earn a fair return on their property investment. In other words, while there is actual and substantial progress toward railroad prosperity, the railroads have not yet attained the goal of a fair return provided for by law at 6 per cent, a figure far more modest than for industry in general.

Since 1920 approximately $4,250,000,000 in new capital has been invested in additional railroad facilities, and about $800,000,000 more will be spent on work contemplated during this year.

The most outstanding demonstration of the recent increase in the capacity and operating efficiency of the railroads appears in the handling of freight during the first half of 1926, which slightly exceeded in volume that in the first half of 1923, the largest amount of business ever handled in the first half of any year previously.

Results show that since 1922, taxes paid by the railroads have exceeded dividends by a substantial margin. The net earnings of about one mile out of every four are now devoted to taxes. Better earnings and therefore greater purchasing power have effected greater stabilization of industry, and in a large measure have contributed to the prosperity which the country now enjoys.

What the railroads have accomplished in the last few years has emphasized anew the fact that adequate railroad service and fair returns are more important to business than railroad rates. Improvement in railroad earnings therefore should be regarded in the light of one of the essential means of providing for the transportation needs of the future.

Reply to Criticism on Train Control

W. J. Harahan, President of the Chesapeake & Ohio Railway Co., and Chairman of the Committee on Automatic Train Control of the Association of Railway Executives, has written a letter to Col. George Harvey, Editor of the *North American Review.*

The letter says, in part:

"The glaring inaccuracies and misinformation in this article to which the author has been unwilling to sign his name, make it necessary to set before you the facts with reference to the subject.

"The railroad managements have no responsibility which is greater and no purpose which is more definite and pronounced than to protect the safety of the traveling public, and when an adequate workable and dependable system of automatic train control has been devised, the carriers will not hesitate to put it into use, particularly on those lines where difficult operating conditions render it advisable to make such installations.

"Due to the many safety measures which the railroads have installed, a passenger is more than four times as safe aboard a train today as twenty-six years ago. In fact, he is safer traveling in a train going sixty miles an hour than he is walking along the street or even in his own home. This is borne out by the fact that insurance companies in their accident policies offer double indemnity to any person killed or injured in a railway accident.

"This increase in the safety of the traveling public has been brought about largely by the voluntary action of the railroads themselves, for, in addition to their regard for human life, the greater the safety of passengers and employees, the greater the efficiency in operation, which is the measure of success in railroad management.

"Installations voluntary made by the railroads of automatic signals, heavier and longer rails, steel cars, steam-heated cars, vestibule equipment, electric lighting, highway crossing protection and other improvements, were made with the object of protecting the public and saving human lives. In addition, millions of dollars are being expended annually in 'safety first' work.

"The article charges the railroads with undue delay in installing automatic train control devices on their lines. Under the order issued by the Interstate Commerce Commission on June 13, 1922, designated as Order No. 1, the railroads were required to equip 7,641 miles of track with train control devices, at an estimated cost of $25,000,000. Under Order No. 2, issued on January 1, 1924, an additional 7,440 miles were ordered to be equipped at a further cost of $25,000,000. Of the 7,641 miles required by the first order, all have been completed except 500 miles which will be finished within the next few months. Under the first order of the Commission, it has been necessary to equip nearly 4,000 locomotives.

"Of the 7,440 miles of track required under Order No. 2, a total of 2,860 miles has been completed on 13 roads and additional mileage is being completed each month. This means that more than 10,000 or over two-thirds of the 15,000 miles required under both orders have been equipped with train control devices which are in operation.

"The two orders of the Commission affect only about 7½ per cent of the total mileage of the Class 1 railroads and to equip all the passenger lines with train control devices, should a practical device or devices be developed, would involve an estimated expenditure of not less than $665,000,000, which cost eventually would fall on the shoulders of the public.

"The article assumes that a practical device has been perfected. It is the opinon of the vast majority of railroad officials, including signal and operating officers, that no system of automatic train control has yet been developed to that state of physical performance which renders it feasible to warrant its application to the railroads on the scale that is necessary to equip the entire country. Many of the train control systems which have been offered are in the experimental stage, not yet having even reached an effective stage of development. The anonymous writer of this article recommends for adoption the system now in use on the Rock Island Railroad. Notwithstanding the fact that this system has been in process of development on that line for a number of years, no other railroad has adopted it. It is inconceivable that in the thorough and strenuous search which the railroads have made for a system to meet operating conditions, they would not further extend the use of any system which would properly meet their conditions.

"The anonymous writer of this article refers in commendatory language to the character of locomotive engineers. The voice of locomotive engineers has been heard with respect to this very problem. Mr. Warren S. Stone, late Grand Chief of the Brotherhood of Locomotive Engineers, testified before the Commission that he felt a new type of accident, more serious than any accident that it could prevent, would be developed by the use of train control which would take the control of the train from the engineman.

"The position of the railroads with respect to the orders on automatic train control issued by the Interstate Commerce Commission has been misrepresented. When the first order was issued the carriers took the position that the requirements of this order were sufficient fully to develop adequate types of train control so as to enable the selection of a practical and workable device. This is still their position. They felt furthermore that this first order had come prematurely and had been issued before experiments with train control systems had reached a stage which justified such extending of the installation. Consequently the carriers felt in respect to the second order requiring a largely increased expenditure that no further action should have been taken by the Commission until the requirements under the first order had clearly shown the extent to which experience had produced a proper device.

"The railroads hope that when the 15,000 miles required under both orders have been equipped, sufficient time will be allowed to elapse so that all the types of train control offered may be developed and placed on as practical a basis as automatic block signals. As a matter of fact, automatic train control only provides against those accidents that may occur from the temporary incapacity or lack of alertness of the engineer, whereas automatic block signals provide against accidents that are liable to occur at any moment. The last statistics issued by the Interstate Commerce Commission show more than one-third of the fatalities due to train operation occur at grade crossings. The elimination of grade crossings would be far more to the public interest than train control, but it is recognized from a practical standpoint that the elimination of all grade crossings would require the expenditure of nearly as much money as it would cost to build the railroads. This would place a heavy burden upon the public and therefore must be done gradually.

"The railroad managements of this country do not set up dollars against safety. They do not feel justified, however, in spending enormous sums of money on the extensive installation of an experimental device when they can accomplish much greater results in the promotion of safety by extending the same amount of money in developing means of providing safety that will affect a greater proportion of the population of this country and will produce greater results in conserving human life and happiness."

The American or 4-4-0 Type Locomotive

By Arthur Curran

As a general proposition, the 4-4-0 type has ceased to figure in the trade press, except on those rare occasions when some technical writer of unquestioned ability has something of interest to say about an engine of undoubted historic importance. Since the type is no longer used in fast passenger service on the big railway systems in the

United States, it is not surprising that editors accord it little space.

However, in the course of modernizing old power, American railways occasionally include some engines of the 4-4-0 type if it can be shown that their use would be advantageous on certain divisions or on subsidiary lines.

In England, as in America, modernization consists commonly in the application of superheaters and piston valves to old engines. Of course, a more elaborate program may be adopted in the case of engines of more modern and powerful type; but the usual procedure is as outlined. The superheater gives an old engine greater smartness and the piston valves are more satisfactory in connection therewith. Disturbance of the valve gear is avoided when possible, in order to curtail expense.

For many years, the most striking examples of the 4-4-0 type in England were those of the "County" class on the Great Western Railway. These engines were equipped with piston valves as built, and, hence, have not required modernization in that respect. Some of them have undergone various changes, however, and all are now fitted with superheaters. The main rods of these engines have a very neat design of big end. The boiler has one straight ring immediately back of smokebox, the rest of the barrel being tapered. The cylinders are 18 x 30 inches, drivers 80 inches, working pressure 200 lbs. and tractive effort 20,530 lbs. The first of these engines appeared in 1904, and there are now 40 of them. As might be expected, the fast trains of today are much too heavy for them, and they have been relegated to less strenuous duties. These they perform with entire satisfaction.

The Pennsylvania Railroad, ever alert in the field of improvement, has modernized a number of old 4-4-0 engines which are now known as Class D16sb. The principal particulars of these engines are as follows: Cylinders 20½ x 26 inches, drivers 68 inches, steam pressure 175 lbs., weight of engine exclusive of tender 141,100 lbs., and tractive force 23,900 lbs. Originally, these engines had slide valves and used saturated steam. Some of them had 80 inch drivers. It will be seen that, though carrying less steam pressure, these engines have greater tractive force than the "County" class of the G. W. R. This is due to the difference in driving wheel diameter, rather than to the variation of cylinder proportions. (There are no more 80 inch 4-4-0 engines on the P. R. R., according to available data.)

4-4-0 Type Locomotive of the Great Western Railway of England

That the modernization of 4-4-0 engines is not so common in America as in England is clear enough, however, this circumstance being due to a number of factors which may be worthy of examination.

Thirty years ago the well-known American type was a more powerful engine than its British cousin, then known as the "four-coupled bogie express." But as time went on, "four-coupled bogie" passed the American type. In other words, the English "got wise" to boiler power and designed their engines so that rather large cylinders could be used.

Perhaps the finest American type engines in this country were those designed for the Pennsylvania Railroad by Mr. F. D. Casanave, and originally known as Class L; later as D16a. They had 80 inch drivers and were thus comparable to the British express engines, but their tractive effort of 17,500 lbs. was much below the figure subsequently attained by English designers with the same size wheel.

Seeing that most of the 4-4-0 engines in this country were far below the P. R. R. standard of power—the common T. E. figure being about 12,000 lbs.—it will be understood readily enough that the English engines easily beat the American.

When, therefore, the time came to consider modernization, the English motive power men found themselves with a fair supply of rather powerful 4-4-0 engines, well worth improvement; and the American ditto found themselves loaded up with a lot of sad old wrecks, just about ready for the scrap-heap and not worth a cent!

4-4-0 Type Locomotive on the Long Island Railroad

As already explained, the P. R. R. is a notable exception, since, by using smaller drivers, larger cylinders and superheaters, its 4-4-0 engines were given a "new lease of life." There may be other interesting cases, but the one cited will suffice.

This explanation is worth while, because at one time various writers were under the impression that useful old-time engines were being scrapped without due consideration. Perhaps if some of us had been sitting behind the "old man's" desk, a lot of engines would have "hit the scrap" even sooner!

Obviously, this is a question of finance as well as of mechanics, since the repair of some old engines involves a greater expense than the "mill" is worth. On the other hand, for engines that have possibilities, various supply concerns offer devices to increase efficiency and prolong usefulness. Experience indicates that nothing smaller than a six-coupled design is worth saving on the majority of American railways. The weight of trains and severity of conditions operate against the small engine in this country, and render its survival impossible.

For the benefit of those who may be interested in a powerful English 4-4-0 design, a photograph of "County of Warwick" is presented herewith. This illustrates the G. W. R. class already mentioned.

Another picture of interest shows No. 223, of the Long Island Railroad, with a train of ten cars. This is one of the superheated 4-4-0 engines of Pennsylvania design to which reference has been made. Though the train consists of wooden equipment, the load behind tender is con-

siderable for an engine of this type. These engines can attain 60 m.p.h. with such a train.

In this connection, it may be mentioned that some 4-4-0 engines, built by Baldwin more than twenty years ago for the L. I. R. R., have been modernized similarly, and can handle the same load at the same speed.

These instances are of interest as showing what can be done with small engines, properly equipped and maintained, but they are the result of careful study of a specific problem and cannot be made the basis of unqualified generalities, since many 4-4-0 engines on various roads would not be worth modernization.

The English 4-4-0 has reached its present development because the "Old Country" retained its faith in the type long after American designers had discarded it as out of date. It is now, of course, out of date even in England, so far as important runs are concerned, at all events; but its usefulness in less exacting classes of service renders likely its continued employment for some time to come.

Aeronautical Transportation

By Richard R. Blythe

The development of commercial air transport has been frequently predicted, but has only just arrived. The new air lines are now settling down to their strides and some conclusions can be drawn concerning commercial aerial transportation in this country. At the present time there are eleven contract air mail routes in operation, each of which has a different sort of problem to solve. Distributed as they are throughout the country, they have adopted different types of planes to meet the different flying conditions met with. It is interesting to note in this connection that eight out of the eleven have purchased the same type of power plant, the Wright "Whirlwind" 200 h.p. air cooled engine.

Although all eleven of the air mail contractors quite naturally agree in carrying the mails, they do not all agree in the carrying of passengers or express. Most of the lines expect to carry express matter in the very near future and some of them have announced their intention of carrying passengers as soon as they can obtain suitable equipment. Two of the contractors are carrying passengers at the present time. They are the Western Air Express, carrying passengers between Los Angeles and Salt Lake City, and the Philadelphia Rapid Transit Air Service between Philadelphia and Washington. The Western Air Express are using their specially built mailplanes, while the P. R. T. are using Fokker "Trimotor" passenger machines, each with three Wright "Whirlwind" engines.

The only line to specialize in passenger carrying is the Washington-Philadelphia service of the P. R. T. For the first two months of their operation, ending September 21st, they have carried 1,553 passengers with a schedule of 94 per cent efficiency for trips completed on time. This large figure with three eight-passenger machines is accounted for by the fact that this service makes two return trips per day. During the two months 29,200 miles were covered in approximately 320 flying hours. One of the principal attractions of this line for passenger traffic is the fact that they use comfortable planes with three Wright engines insuring safety and reliability.

Another factor in attracting this large number of passengers was the excellent field arrangements for their comfort. An attractive brick pavillion has been erected at each of the terminal fields. These buildings provide waiting and rest rooms for the passengers as well as a news and refreshment stand. Neat fences prevent the passengers from wandering around the flying field and so endangering themselves and the planes. Access to the planes is had through a lane formed by two open gates so placed as to avoid any possibility of getting near the whirling propellers. The pavilions also contain the field mailing rooms and the flight officers' quarters. The equipment is taken care of in two commodious metal hangars. These buildings were designed and constructed by the William E. Arthur Company, who have built so many airports.

A new P. R. T. air schedule which includes an additional trip between Philadelphia and Washington went into effect on September 15.

Lieutenant Bertrandias states that the air line between Philadelphia and Norfolk illustrates the advantages of air travel for speed, as the air line has a 3½ hour flying schedule with a 15 minute lay-over in Washington. By train, the trip takes 9½ hours, and frequent train changes are required at technical points.

The price of a journey from Philadelphia to Norfolk is $60 a round trip, with a $35 one-day fare. The prices from the city to Washington will remain at $15 one-way and $25 a round trip. The rates from Washington to Norfolk will be $20 one way and $35 for the round trip.

The daily flight to Norfolk will be made at 9:30 a. m. from Philadelphia and the plane will leave Norfolk for Philadelphia at 2:30 p. m.

Roller Bearings on Pullman Cars

The Chicago, Milwaukee & St. Paul Railway recently changed its policy of building and operating its own sleeping cars and recently placed a contract with the Pullman Company similar to that in force on most railroad systems. The Pullman Company has agreed to place roller bearings on new sleeping car equipment valued at $2,000,000 as an experiment, and the first cars so equipped will be placed on the C. M. & St. P. cars. It is expected that the roller bearing equipped sleeping cars will eliminate much noise and the annoyance of passengers due to the jerking action incident to the starting and operating of the present heavy Pullman equipment.

Railroads Order More Gas-Electric Cars

Additional railroad companies including one in Canada have placed orders for Brill Westinghouse gas-electric cars. One of the railroads, the Reading Company, is placing its second order for this type car having already placed in operation the first Brill-Westinghouse car ever built. This car was delivered and put into operation in August of last year.

The other orders received were from the Wheeling & Lake Erie Railroad and the Temiskaming & Northern Ontario Railroad Company.

The Reading Company's order calls for three standard designed 60 ft. passenger and baggage cars with the standard 250 horse-power gas-electric generator units and all the other construction features embodied in previously delivered cars. When completed and delivered to the railroad these cars will be operated in the service between Trenton and Bound Brook, N. J., it was announced. The order received from the Canadian Railroad calls for one 73 ft. passenger and baggage car which is to be delivered at the line's headquarters at North Bay, Ontario. On the other hand the contract placed by the W. & L. E. Railroad calls for two 60 ft. passenger and mail cars and one 60 ft. passenger and baggage gas-electric car.

As in the past all the cars will be assembled at the Brill Works while the motive equipment will be furnished by the South Philadelphia and East Pittsburgh Works of the Westinghouse Electric and Manufacturing Company.

Locomotive Availability and Roundhouse, Terminal Facilities, and Methods

Committee Report to the Traveling Engineers' Association, P. O. Wood, Chairman

Your Committee has assumed that in selecting the title "Locomotive Availability" it was the desire to bring before this Association, and to open for discussion and food for thought the utmost practical and economical utilization to which the modern steam locomotive is capable when properly cared for, handled and supervised, and the maintenance of same in as nearly perfect or 100 per cent condition as necessary to meet the requirements of service without preferential handling of repairs on the part of employees of the mechanical department.

The capital outlay necessary for the purchase of a modern locomotive of today will run $65,000 to $100,000 and up. The railroads have earnestly endeavored to supply themselves with sufficient locomotives and other equipment of suitable size and capacity to serve the shippers over their lines without unnecessary delay. There is no question before the transportation and mechanical departments of our American railways today of more importance than the movement of traffic with dispatch and the maximum use of their equipment.

You have all read with interest of the spectacular runs that have been made, and which are being referred to almost monthly in our various magazines and newspapers. They may be intensively supervised and not representative of the practical limitations of the various roads in question. They are, however, forerunners of a new trend of thought, and where continuity of trackage as regards grade line and volume of traffic are favorable, the mechanical condition of the locomotives and operation on the part of crews can with proper co-operation of all parties affected be worked out successfully. It is very apparent that if a locomotive can successfully handle a train of 500 to 1,000 miles or more, and arrive at the destination without a failure or delay and with fire in good condition, it should remind us that there are great opportunities for improved locomotive and firing conditions on runs that are relatively short, and we should set our standards higher for all classes of service.

Regardless of the apparent mass of intricate appurtenances on our locomotives of today, the running gear and boiler have really been simplified; the extension of grease lubrication to rods and boxes and the lateral plates of engine trucks, drivers and trailers; ample oil cellars on valve gear, and knuckle pins;—gas furnace carbonizing, and the perfect grinding and fitting of case-hardened valve parts subject to wear; self-adjusting wedges; steel end sills, steel tank frames, tank truck frames, and engine truck frames, case-hardening of brake and spring rigging pins and bushings has been the trend of shop practices, all of which eliminates renewals or greatly prolongs the periods between renewals, permitting the supervision to furnish engines more promptly and to utilize the power more regularly per engine in service; it also permits offering power in a more nearly perfect condition even with the high pressures and high superheat developed. The use of returned valve rings and dependable drifting valves and the help we have received from better refining and filtration of lubricating oils has greatly prolonged packing renewals.

Syphons, arches, flexible bolts, alloy and heat-treated steels, electric welding of flues, plenty of washout plugs properly located to keep the sheets and tubes clean, and, the most important of all, a dependable water treatment makes it possible to dispatch power promptly. The application of blow-off cocks intelligently used and coupled into mufflers so they can be used at any time and place, will prolong not only the life of the flues and fire-box, but will cause water used in the locomotive having widely varying characteristics to be so controlled that pre-determined boiler washing periods can be planned for each territory or grouping of territories in advance. A recent test in a bad water territory was made by the Test Engineer with a boiler on a Mountain type passenger engine handling fourteen coaches on a run of 543 miles. The water at the initial dispatching point contained 25.2 parts dissolved solids per 100,000 fill-up water. The boiler had just been washed and after running 145 miles there were 164 parts dissolved solids; but by regular use of the blow-off cocks on each sub-division two round trips totaling 2,168 miles were completed. The engine was in charge of sixteen different engine crews during this time, and on arrival at the point where originally dispatched the water in the boiler analyzed 154.8 parts dissolved solids per 100,000, the water being clearer and freer from dissolved solids after completing a mileage of 2,168 miles than it was after running 145 miles from the point where the boiler was washed. The control of this condition makes it possible for the locomotive to make longer mileage and use water with a wide variation in analysis, thus enabling Roundhouse Foremen to figure on and furnish more promptly power that is more dependable.

The mechanical conditions referred to have transferred to our general repair shops a heavier first cost of repairs. The wisdom of doing a better class of work is apparent in our back shops, which proves an investment later by relieving our roundhouses and running repair gangs of constantly renewing parts that can and do run from one general shopping to another. All of these efforts are to make possible the increased availability of the locomotive; increase its earning power; reduce the percentage of engines out of service; reduce the cost of roundhouse maintenance gangs, and insure the locomotive making its expected mileage and following a predetermined shopping program for the particular class of engines involved. Since roundhouse maintenance is not constructive, it follows that there is no such thing as an engine accumulating mileage and being in 100 per cent condition. The engine may be in 100 per cent condition when put out of the general shops, but each day and mile of service will build into this engine wear and tear that is deferred maintenance. The roundhouse forces strive to keep the engine in condition. As practical men we have knowledge of their limitations, and even our effort to eliminate wear as developed would set up such excessive costs that the plan would not be practical. All repair work in back or general repair shops is constructive, as an old engine is taken in and the work done on it brings it back to as nearly its original condition as possible. Therefore the 100 per cent condition is taken to mean as nearly perfect condition as practical and as the demands of the service require.

In approaching the question of locomotive availability

through a greater utilization of the power and considering the human element which if not given serious thought is sure to result in failure, there are several factors to consider. Among the first are custom or past practices, long established; failure of the management to educate the employees to the extent that they will heartily co-operate, and if not oppose at least be lukewarm; failure of the subordinate officers to realize the magnitude of the capital expenditure involved and the resultant interest and depreciation charges, and the savings that will accrue through greater power utilization, and resultant increased mileage and tonnage handled per locomotive per year.

The extension of locomotive runs means more exacting conditions; power placed ready for service that is in fit condition in every respect; starting on one or a very few selected runs intensive supervision by practical and unprejudiced men in both transportation and mechanical departments; all work so arranged that no undue hardship will be imposed on any member of the crew; on the other hand, all work that the crew should perform as part of their regular duties to be exacted at the proper place and time; care in the distribution of coal so although many grades of coal are used the coal on each division will be up to contract specifications, such fuel as the particular crew expects and is familiar with its handling; the elimination of delays at intermediate terminals that would tend to destroy proper fire conditions and handicap the outbound crew. Supervision should stay with the runs until every detail is worked out to the satisfaction of the men; do not get off the job, leaving the men with some almost impossible condition to contend with, or in other words with a sack to hold, and the entire plan will later die a natural death through neglect and failure of supervision to promptly and thoroughly take care of such conditions as might come up. The locomotive will respond regularly and dependably to a service beyond our past efforts and up to our most optimistic expectations with greatly increased earning power per locomotive.

At intermediate points that suffered through congestion from lack of adequate facilities it will be found that by extension of locomotive mileage and whiteleading of surplus power the contemplated capital expenditures can be transferred to the initial and final terminals after a rearrangement of the mileage is made, and substantial reductions in engine handling and maintenance forces, and also standby or terminal fuel savings will result. Greater net economies will follow a general extension of mileage of all runs than excessive extension of a few runs on account of the former policy permitting curtailment of forces at intermediate terminals.

In the locomotives of the future will be embodied larger boilers with high boiler pressures, with larger grate areas, superheated steam for all auxiliaries, such as booster, air pumps, feed water heaters, etc., short or limited cut-offs at slow speeds which provide greater expansion of steam with proportional saving fuel and resultant increase in available tractive power.

On long distance runs where occasional short heavy ascending grades are encountered and where stops or slow-downs are made, the future locomotive is available with its surplus booster power to carry it over such obstacles where the locomotive would have been replaced by a larger one with no booster in the days when short runs were made.

Proper counterbalancing of the reciprocating and revolving parts relieve the locomotive of unnecessary stresses. By the use of alloy and heat-treated steel parts it is possible to design reciprocating parts strong enough and light enough to be able to get a complete balance so that there may be no restriction of speed necessary. A locomotive improperly counterbalanced is not capable of handling the tonnage that a properly counterbalanced locomotive should handle due to speed restrictions necessary to prevent damage to the track.

By the use of cut-off control gauges it is possible to adjust the throttle and reverse lever to the best operating conditions so that the locomotive will not be working against a high back pressure. The engineer usually sets his lever in what in his opinion is the best working notch, taking into consideration the tonnage, schedule and grade; but this is not always the proper location for efficient and economical handling. The gauge also indicates when the pistons are pulling a vacuum when drifting. By the use of a cut-off control gauge he is provided with a guide to tell him what he is doing, and this knowledge coupled with his skill and judgment helps to eliminate guesswork and the wide variations of locomotive operation.

The engine crews should be schooled in the proper manipulation of the feed water heater, exhaust steam injector, booster, etc., so that they may be operated at the most suitable time, and in the most economical manner consistent with the service.

The proven fuel-saving devices, such as superheaters of high degree, boosters, feed water heaters, or exhaust steam injectors, syphons, arches, improved design of grates, the larger use of steel castings replacing cast iron, larger use of alloy steel for increased strength and lighter weight, more liberal fire-box design and higher steam pressures—all these are basic improvements enlarging the capacity of the locomotive and building into the locomotive ability to develop greater horsepower not only to start its train, but one of the most important advantages is the handling of tonnage at greatly decreased fuel consumption and at much higher rate of speed, all of which increases the locomotive's availability and enlarges its field of usefulness. This increased availability of our modern locomotive has been quickly recognized by wide-awake executives responsible for the economical operation of our railroads, with the result that where local conditions will permit tradition has been sidetracked and operating economies are being put into effect, and our railway executives are putting up to their subordinates and to the officers and employees of the mechanical departments daily new problems which demand of the locomotive greater efficiency, economy of operation, and greater use of its potential availability, and of the men greater vision, greater understanding, co-operation, helpfulness and an open mind, a careful study and knowledge of possibilities and also limitations based on local conditions.

Up-to-Date Locomotive Terminal Facilities

The striking advance in locomotive design witnessed within fifteen years is generally conceded to have been the salvation of railway operating ratios during the greatest period of expansion occurring in rail transportation. Had development of the steam locomotive ceased fifteen years ago we would now be faced with a serious car shortage and extravagant operating costs threatening to bankrupt many lines. Under these conditions the railroads would be hastening to electrify as rapidly as their financial resources permitted, and a general state of dissatisfaction with the entire transportation machine would undoubtedly exist.

Now that we have improved stoker-fired steam locomotive which compares much more favorably than formerly with the best stationary steam practice in efficiency, more thought must be given to improved terminal facilities. The efficiency of a modern steam locomotive under favorable operating conditions is already so

high that we cannot anticipate any radical improvement in this direction. Does this mean that if motive power efficiency is to be further improved it must be in the direction of the Diesel engine of electric traction? Further economies of the modern steam locomotive will depend largely upon our ability to eliminate stand-by and terminal losses to which this type of power is now subjected, and reduce its non-revenue hour ratio.

Two of the strongest economic arguments in favor of electrification or the Diesel locomotive are the elimination of terminal losses; not only the loss of fuel consumed by steam locomotives during their lay-over periods, but loss on the investment incurred by locomotives standing idle at terminals. Statistics show that steam locomotives on all Class 1 railroads average only about one-third of the time in revenue service and that at least 20% of all locomotive fuel is consumed at terminals. These investment and fuel losses can be largely eliminated by electrification or practical development of the Diesel locomotive and by improved terminal facilities.

Had the efficiency with which locomotives are handled at the terminal been improved in proportion to locomotive operating efficiency, the situation would be different, but the facts are that at a majority of terminals there has been no fundamental improvement in type of facilities or method of operation. Where enginehouses have been enlarged and are better built, turntables have been lengthened and designed to operate more rapidly, coaling stations and fire-cleaning facilities have been perfected, as well as sufficient drop pits for handling of driving wheels, engine truck and trailers, and with the advent of solid cast steel frames and three-wheel tank trucks, drop pit facilities should be provided for handling them quickly. Light electric traveling cranes operating on a monorail the full length of the roundhouse circle and between all drop pits speed up the work and make available for dropping of wheels the entire group of drop pits, so it is not necessary to keep one pit clear for wheel handling. Use of depressed spring tracks for handling spring work not only speeds up several times the application of springs and spring hangers, but greatly reduces the hazard where engines are jacked to relieve weights and where spring pullers are used. A suitable hot water wash-out plant is a necessity, as also are blower lines of ample capacity.

Mechanical coaling and ash-handling plants are a great improvement over coaling with Brown hoists and installing of dangerous water cinder pits. Ventilation, heating and ample flood lighting are all part of modern terminal facilities that speed up work and promote health and safety. There is no excuse for poor drainage for an electrically operated and automatically controlled centrifugal pump in a sump can be installed at low cost and will operate with very little attention almost indefinitely. A new departure from the old established routine handling of locomotives at terminals and with possibilities next to advantages derived from hot water wash-out plants is the installation of direct steam for making ready engines at terminals. Proof of the practicability of this plan of speeding up the turning of power at terminals is the recent installation of direct steaming plants at the new Grand Trunk Western Locomotive Terminals at Battle Creek and New Chesapeake & Ohio Terminals at Russell, Ky., and installations contemplated at Chicago and other locations. Engines handled under this method are put into the house with fires knocked; the boiler is filled through the blow-off valve with a mixture of live steam and hot water entering the boiler at steam temperature, heating all sections of the boiler rapidly and uniformly; the water is shut off when it shows in the glass and the engine is held on the steam connection until it builds up to working pressure and held on this connection and pressure until ordered bedded down, and when ordered moved out of the house the fire is lighted and the engine's own blower used until the fire is fully caught. Absence of smoke and gases in the roundhouse, availability of the engine for quick call, ability to take the engine on quick call and immediately move out of the house to outbound ready tracks under own pressure, making house room available, and automatically enlarging the capacity of the roundhouse, pressure of steam on the boiler to expedite spotting for work, and use of steam from an efficiently operated stoker-fired, forced draft, slack-burning power plants as against expensive steam consumption from the house blower and new inefficient green fire just started in the locomotive, are some of the advantages claimed during the time the engine is having steam raised to working pressure.

Engines filled with water to the gauge and brought to working pressure in one hour, including filling car, if bedded previously but not lighted, be dispatched on fifteen-minute order for the engine.

This method seems to be both a radical departure and at the same time present installations indicate a practical and economical advancement in locomotive terminal facilities.

Up-to-Date Methods

The third part of the subject, "Up-to-Date Methods," naturally will bring us back to the shops, roundhouses and mechanical organization.

Two and one-half years ago on one of our leading railroads a check for a thirty-day period was made, and 1,800 engines were considered in this check; the freight divisions and freight engine runs averaging 100 miles and passenger divisions and engine runs seldom over 200 miles. The record was fairly representative of revenue and non-revenue hours per locomotive of similar roads at that time, prior to extension of locomotive mileage over more than one division. The results of the check indicated that each locomotive spent six hours and fourteen minutes or 26% of the period in the roundhouse for repairs, testing, washing, etc. After being ready for service it spent six hours and twenty-six minutes or 26.8% of the period awaiting a call from the operating department. It was in actual service six hours and forty minutes or 27.8% of the period. Fifty-five minutes or 3.8% of the period was consumed on the engine track for fire cleaning, coaling, sanding, supplying, etc. One hour and twenty-two minutes or 5.7% of the period was credited to storage or whiteleading, while one hour and fifty-seven minutes or 8.1% of the period was credited to classified repairs, and twenty-six minutes or 1.8% of the period was credited to waiting for classified repairs. It is needless to state that as a result of this time study great improvement was made.

The foundation of good locomotive maintenance is correct design first, then the use of proper materials and first-class and thorough general shop repairs at intervals based on a predetermined mileage governed by the type of power and local conditions; this must be supported by boiler work and bolting of such substantial nature that this part of the locomotive can practically be laid by when later roundhouse running repairs are considered, and returns on this investment more than justify the back shop policy. The purchase of modern heavy duty machine tools only should be considered; they are to be concentrated at the general shops, and the older or more obsolete types of machine tools from the back shop transferred to the smaller outside points where quantity production methods are not so important. The grouping of all machine tools necessary to complete operation on the major parts of the locomotive in the general shop

are worthy of deep study, and the relation of this grouping to adequate crane service for the heavier operations is important.

Intensive supervision and specialization is necessary in general shop work. A complete scheduling or routing is important. A uniform routing system of engines in shops will avoid the rush and demoralization in the last few days of the month and keep stripping, testing and wheeling in proper rotation and the machine shops constantly supplied with work.

The ability of machine tool manufacturers to produce modern tools that speed up the heavier operations is outstanding. The use of Oxygraph cutting machine, modern millers, rod machinery, annealing furnaces for frames, rods, etc., and carbonizing furnaces, normalizing processes and many other improved methods are the medium of putting into service our modern locomotives so they can economically and safely negotiate runs of 500, 1,000 and more miles now and in the future with dependability.

The requirements of the Interstate Commerce Commission Division of Locomotive Inspection and Locomotive Boiler Inspection Law have proven to be a blessing to the railroads of this country. Not only does it standardize locomotive conditions, but the mechanical department officers take advantage of the monthly, quarterly and many other stated inspection periods to add to the Federal requirements many additional inspections of a precautionary character of their own that tend to maintain the locomotive in a much higher state of efficiency.

On monthly inspection periods the appurtenances of the locomotive should receive special attention, stoker bearings repacked, injectors and checks cleaned out, superheaters, water tested, valve and cylinder packing examined, syphons bombarded. By following a policy of close inspection at stated intervals the various devices are maintained at a high standard of efficiency. This class of work on locomotives should be handled by a force of specially trained men.

The running repairs are so dependent on good inspection and work reports rendered that to expedite the handling of the power the locomotive inspectors should have their work so arranged at suitable outside inspection pits for inbound engines either prior to or after fires are knocked or banked that engine can be spotted and thumped and the foreman will have the inspector's report available when the engine handling is completed. In cold weather staggered hours of inspectors on duty prior to mechanics' working hours makes available the report and speeds up the turning of power. A four-inch magnifying reading glass is a great aid to inspection. There should also be complete outbound inspection.

At large engine-handling terminals a complete record filed of all work reported and signature of the mechanic performing the work is necessary. The use of floating bushings on heavy power permits the renewals of rod brasses for wear without the removal of the rods, except when handling the middle connection brasses; there is also no time spent for re-tightening loose brasses in rods.

Grease lubricated lateral plates of drivers on small power operating on an extremely crooked mountain railroad will run from shopping to shopping without having to drop wheels for lateral wear. Santa Fe and Mountain type engines will run from the time out of the general shop to the time shopped for Class 5 repairs, averaging 40,000 miles in freight service and 60,000 miles in passenger service, with no necessity to shop for taking up of lateral. Grease lubricated engine truck and trailer lateral plates that are removable and can be renewed in thirty minutes by one man greatly prolong mileage and expedite repairs, as well as increasing the serviceable engine hours of locomotives.

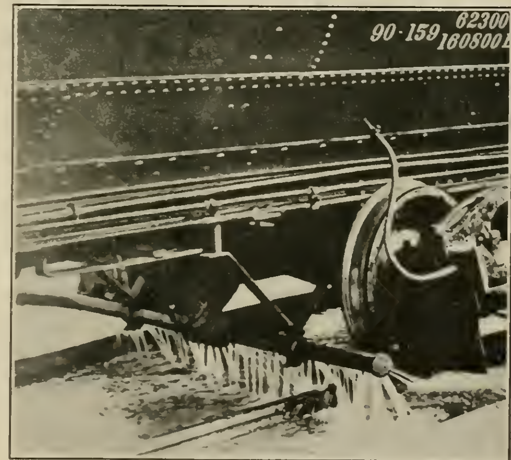
Traveling company federal inspectors with authority to tie up power for defects are a great help in maintaining power at a high standard. These men examine all foremen and company inspectors on federal rules and grade them, and soon train a very efficient force of inspectors and qualify all foremen on the requirements of the federal rules. A traveling valve expert soon trains the mechanics selected at division points to look after valve gear and valve setting on the most acceptable methods of handling this class of work and maintaining valve parts to standard. This cost is repaid many times in fuel saved and uniformity of methods.

The test engineer and his associates supervise and check the efficiency that is being gotten from our special appliances, such as pyrometer tests of superheaters, temperature tests of feed water heaters, indicator, and comparative check of fuel consumption. This keeps the division people alive to the necessity of having their organization so perfected that there will not be a loss in efficiency of the engines so equipped.

One of the greatest aids to maintain a high degree of efficiency is for the operating officer to set his mark so high and the service so exacting, and follow up any failure to attain the standards set, that all concerned will be compelled to keep in good condition the locomotives and the various devices on them which are intended to increase their capacity and to save fuel.

Dustless Steam Railroad Transportation

For many years railway companies have carried on an expensive, but largely unsuccessful, attempt to rid passenger transportation of dust, which has ever been a burdensome annoyance to dry-weather travel. Seeking refuge on the "observation end" from the stuffy, dusty interior of the car, only to be driven inside again by worse dust



Sprinkler for Railway Roadbed

encountered on the outside, is an experience unpleasantly remembered by all of us.

Railway operators have spent hundreds of thousands of dollars in spraying their rights-of-way with crude oil only to find that the dust soon formed a coat over the oil, and the evil sought to be destroyed was aggravated. Furthermore, the oil acted as a lubricant to the ballast, causing it to "work" under the load of the heavy trains, with consequent destruction on the line and surface of the tracks

and added expense for maintenance and transportation.

W. H. Whalen, of Los Angeles, former superintendent of the Los Angeles division of the Southern Pacific, which covers a district particularly scourged by dust in the long stretches of desert country, solved the problem by the simple means of spraying the roadbed under the moving train with water taken from the locomotive tender. He has developed and patented a sprinkling device, operated by the locomotive fireman, whereby this is accomplished.

By this means a quantity of water sufficient to lay dust is sprinkled beneath the tender, between the rails and for a distance of about three and one-half feet on either side of them, wherever dusty stretches of track are encountered. Signal flags of distinctive design are placed along the right of way to indicate to the engine crew the places where sprinkling is required. The water is taken from a point high enough above the floor of the tender tank to insure an adequate reserve supply to meet the requirements of the locomotive. Ballast is unharmed, as the water used quickly evaporates.

Development of the sprinkler has demonstrated that it has several uses in addition to that for which it was designed. It has proved quite effective in preventing fires in bridges and other wooden structures in the right-of-way. This is of interest to logging railroads, with whom the danger of costly fires, caused by hot coals falling from the fire box or by sparks from the brakes, is ever present. Another advantage is that the absence of dust permits the train crew to detect the smoke arising from hot brake shoes. And not to go unmentioned is the fact that sprinkling the tracks produces a noticeable reduction in temperature on passenger trains—a most welcome relief to the heat-weary traveler. Further, it has been found to be one of the most effective means of eliminating hot bearings on passenger equipment. This is traceable to the fact that sand and dust no longer flies in the air underneath the passenger train and for that reason does not enter the oil box weighting down the packing to a point where it no longer is in contact with the journal; hence lubrication ceases, resulting in hot bearings accompanied by train delay.

After testing this device for about four years the Southern Pacific has found it effective and economical. The Union Pacific has followed the lead of the Southern Pacific and is now preparing to do likewise.

Boiler Gage Light Resists Vibration

Up to this time most boiler gage lights could not stand up under the severe vibration such a piece of equipment is subjected to, and having this in mind, the Westinghouse Electric & Manufacturing Company recently designed and placed on the market a light which it claims will overcome this difficulty. This light consists of a tubular reflector with a bayonet attachment to the socket. So that neither the reflector nor the lamp can loosen under vibration, a compression spring is used to maintain the connection and to hold the lamp in place.

Design of the boiler gage light permits mounting on the guard rail of any boiler water gage or on the end of a ½-inch conduit used to carry wiring to the reflector. This mounting may be accomplished by the use of a screw driver. When it becomes necessary to change the lamp, no tools are needed to remove the reflector because one turn of the reflector disengages the bayonet attachment, and the lamp can then be screwed out of the standard socket.

Heavy brass tubing with a slot in one side to throw the light on the water gage only is used for the reflector. The reflector is easily adjustable for any desirable mounting height and the mounting brackets are arranged to accommodate a wide range of positioning of the guard rods with relation to the gage. A 48-in. two-way conductor cord

Boiler Gage Light That Resists Vibration

and an attachment plug are furnished regularly with the boiler gage light. A standard tubular Mazda B lamp with T-10 bulb is used.

Motive Power Condition

Locomotives in need of repair on September 15 totaled 9,386 or 15.0 per cent of the number on line, according to reports filed with the carriers with the Car Service Division of the American Railway Association.

This was an increase of 355 locomotives over the number in need of repair on September 1 at which time there were 9,031 or 14.4 per cent.

Of the total number of locomotives in need of repair on September 15, this year, 5,026 or 8.0 per cent were in need of classified repairs, an increase of 265 compared with September 1, while 4,360 or 7.0 per cent were in need of running repairs, an increase of 90 compared with the number in need of such repairs on September 1.

Serviceable locomotives in storage on September 15 totaled 5,086 compared with 5,432 on September 1.

Notes on Domestic Railroads

Locomotives

The New York Central Railroad has ordered 12 eight-wheel switching type locomotives from the American Locomotive Company. They are to have a total weight in working order of 219,000 lbs.

The Belt Railway of Chicago has ordered 5 eight-wheel switching type locomotives from the Baldwin Locomotive Works.

The Louisville & Nashville Railroad has authorized the purchase of 18 Mikado type locomotives.

The New York, Chicago & St. Louis Railroad is inquiring for 4 Pacific type locomotives.

The Western Railroad of Minas Geraes, Brazil, has ordered 3 locomotives of the Pacific type from Saechsiche Maschinenfabrik-yorm, Germany.

The Argentine State Railways have ordered 20 Santa Fe type locomotives from the Baldwin Locomotive Works.

The Pennsylvania Railroad has ordered 4 electric locomotives from the Westinghouse Electric & Manufacturing Company.

The New York Central Railroad has ordered 3 three-cylinder locomotives for service on the Indiana Harbor Belt Railroad from the American Locomotive Company. They are to have a total weight in working order of 286,000 lbs.

The Norwood & St. Lawrence Railroad has ordered one Mogul type locomotive from the Baldwin Locomotive Works.

The Louisville & Nashville Railroad is inquiring for 18 Mikado type locomotives.

The Birmingham Southern Railroad has ordered 2 eight-wheel switching type locomotives and 2 six-wheel switching locomotives from the American Locomotive Company.

The Central Railway of Brazil has ordered 18 Mikado type locomotives from the Baldwin Locomotive Works.

The Brownell Improvement Company has ordered 4 four-wheel tank locomotives from the American Locomotive Company.

The New York Central Railroad has ordered one 4-6-4 type locomotive from the American Locomotive Company.

The Mukden Hailung Railway of China is inquiring for 2 passenger type locomotives and for 4 switching type locomotives.

The Orange & Fredericksburg Railroad has ordered one Mogul type locomotive from the American Locomotive Company.

The Southern Pacific Railroad is expected to enter the market for 3 Pacific type locomotives and 10 4-10-2 type locomotives.

The Sudoesta de Bahia, Brazil, has ordered 3 Pacific type locomotives from the Baldwin Locomotive Works.

The Manila Railroad has ordered 3 three-cylinder Pacific type locomotives from the Baldwin Locomotive Works.

The Pennsylvania Railroad has ordered the electrical equipment for 8 new electric locomotives.

The Richmond Fredericksburg & Potomac Railroad has ordered 4 Pacific type and 2 six-wheel switching type locomotives from the Baldwin Locomotive Works.

The Sir W. G. Armstrong Whitworth & Company, Ltd., will build 25 heavy freight locomotives for the Queensland Government Railways.

The Canadian Gypsum Company has ordered 3 four-wheel tank locomotives from the Montreal Locomotive Works of the American Locomotive Company.

Passenger Cars

The Chicago & Northwestern Railway has ordered 100 steel passenger cars, 23 baggage and smoking cars, 10 steel baggage cars and the rebuilding of 35 steel passenger units.

The Consolidated Railroad of Cuba has ordered 6 gasoline rail motor cars from the J. G. Brill Company, Philadelphia.

The New York, Chicago & St. Louis Railroad is inquiring for one gas electric passenger car.

The Pennsylvania Railroad is placing orders for the electrical equipment for 128 multiple unit cars.

The Great Northern Railway is inquiring for 5 motor car trailers.

The Maryland & Pennsylvania Railroad has ordered one gas electric passenger motor car from the Electro Motive Company.

The Union Pacific Railroad has ordered 7 steel baggage and sleeping cars from the American Car & Foundy Company.

The Chicago & Northwestern Railway has ordered 5 70-foot gas electric mail baggage and passenger cars from the Electro Motive Company, and also inquiring for 28 steel coaches of different type.

The Middletown & Unionville Railroad has purchased one combination passenger and baggage gasoline car from the J. G. Brill Company, Philadelphia.

The Louisville & Nashville Railroad has authorized the purchase of 22 passenger cars, 2 combination passenger baggage, 2 diners and 2 postal cars.

The Long Island Railroad is inquiring for 60 passenger motor cars and 30 trailer cars for electric service; 20 passenger cars for steam service and 4 combination passenger and baggage cars.

The Southern Pacific Railroad is reported to be in market for 20 70-foot steel baggage cars, one club car, 10 72-foot steel coaches and 5 72-foot three-compartment steel coaches.

The Chicago & North Western Railway has ordered 4 dining-cars from the Pullman Car & Manufacturing Corporation.

The New York, New Haven & Hartford Railroad is inquiring for 10 steel underframes for baggage cars.

The New York Central Railroad has placed orders for 124 cars for passenger service.

The Middletown & Unionville Railroad has ordered one combination passenger and baggage gasoline rail motor car from the J. G. Brill Company, Philadelphia, Pa.

Freight Cars

The Chicago & Northwestern Railway has placed orders for 500 stock car bodies with the Illinois Car & Mfg. Company. They are also inquiring for 100 steel underframes.

The American Refrigerator Transit Company has ordered 500 refrigerator cars from the Pressed Steel Car Company, 500 from the General American Car Company and 1,000 from the American Car & Foundry Company.

The Louisville & Nashville Railroad has authorized the purchase of 1,000 steel gondola cars, 250 steel underframe flat cars and 250 automobile cars.

The Missouri Pacific Railroad is inquiring for bids on 3,000 to 4,000 freight cars.

The Wabash Railway is reported to be building 24 caboose cars in its own shops.

The Burlington Refrigerator Express Company is inquiring for 200 steel underframes and 200 center sills.

The Cities Service Tank Line has ordered 30 tank cars from the American Car & Foundry Company and 30 tank cars from the General American Tank Car Corporation.

The Paulista Railway, Brazil, is inquiring through the car builders for 50 refrigerator cars.

The Norfolk Southern Railroad is inquiring for 100 complete gondola cars of 50 tons' capacity.

The Consolidated Coal Company has placed an order for 100 mine cars with the Lorain Steel Car Company.

W. W. Boxley & Sons have ordered 6 air dump cars from the Koppel Industrial Car & Equipment Company.

The Chicago, Milwaukee & St. Paul Railway is inquiring for 1,000 automobile cars and for 1,000 stock cars.

The Central of Georgia Railway is inquiring for 20 caboose car underframes.

The New York, New Haven & Hartford Railroad is asking for bids on steel parts for rebuilding 500 40-ton box cars.

The Buffalo, Rochester & Pittsburgh Railway has heavy repair orders pending on about 750 steel hopper cars.

The National Tube Company, Pittsburgh, Pa., is inquiring for 14 skelp cars.

The Lion Oil Refining Company, Kansas City, Mo., is inquiring for 150 tank cars of 8,000 gallon capacity.

The Missouri, Kansas, Texas Railroad is inquiring for 250 freight cars.

The Chicago & Great Western Railway has ordered 300 box cars and 200 automobile cars from the Pullman Car & Manufacturing Corporation.

The C. A. Sims Construction Company has ordered 6 air dump cars from the Koppel Industrial Car & Equipment Company.

The Youngstown Sheet & Tube Company is inquiring for 28 slag cars.

The Great Northern Railway is inquiring for 500 underframes for automobile cars.

The Lehigh Coal & Navigation Company has ordered one air dump car from the Koppel Industrial Car & Equipment Company.

The Long Island Railroad is inquiring for 5 caboose cars.

The Palace Poultry Car Company has ordered 100 poultry cars from the Illinois Car & Manufacturing Company.

The Pacific Fruit Company is inquiring for 500 steel underframes.

The Pittsburgh Steel Company has ordered 6 air dump cars from the Koppel Industrial Car & Equipment Company.

The High Point Thomasville & Denton is inquiring for 25 all steel box cars.

The Southern Pacific Railroad will build 500 50 ton single sheathed box cars in its own shops.

Buildings and Structures

The Chicago & North Western Railway has awarded a contract to Joseph E. Nelson & Sons, Chicago, for the erection of a steam generating plant at its shops at Antigo, Wis., to cost approximately \$65,000.

The Fairport, Painesville & Eastern Railroad it is reported has had plans prepared for a machine shop and enginehouse at Fairport, Ohio, to cost approximately \$75,000.

The Florida East Coast Railway has been awarded a contract for the construction of water station improvements and a treating plant at New Smyrna, Fla., to cost approximately \$75,000.

The Chicago & Eastern Illinois Railway has awarded a contract to the Roberts & Schaefer Company for the construction of a 400-ton capacity reinforced concrete, Simplex automatic, electric coaling and cinder plant at its new terminal at Evansville, Ind.

The Atchison, Topeka & Santa Fe Railway is asking bids on a storage plant at Newton, Kan., and also for an eighteen stall enginehouse at Clovis, New Mexico.

The Cleveland, Cincinnati, Chicago & St. Louis Railway will be asking for bids for the construction of buildings in connection with the construction of the Riverside yard and engine terminal at Cincinnati, O.

The New York, New Haven & Hartford Railroad has awarded a contract to Roberts & Schaefer Company for the construction of a 50-foot high coal pocket at Lowell, Mass.

The Southern Pacific Company plans an ice plant, including facilities for icing refrigerator cars, at Fresno, Calif, to cost approximately $150,000

The New York Central Railroad has awarded a contract to the National Boiler Washing Company, Chicago, Ill., for the installation of a boiler washing and filling system for locomotive boilers in engine house at East Syracuse, New York, to cost approximately $70,000.

The Texas & Pacific Railway has awarded a contract for the construction of a one-story brick valve motor shop at Marshall, Texas, to cost $15,000.

The New York, New Haven & Hartford Railroad has awarded a contract for the alteration of its enginehouse at Readville, Mass., to the J. W. Bishop Company, Boston, Mass.

The Michigan Central Railroad has awarded a contract for the construction of a ten-stall reinforced concrete roundhouse at Windsor, Ont., Canada, at a cost of $110,000.

The Missouri Pacific Railroad has awarded a contract for the construction of powerhouse and enginehouse at Osawatomie, Kan.

The Southern Illinois & Kentucky will construct a 500-ton reinforced concrete coaling station at Reevesville, Ill.

The Kansas City Southern Railway is said to be considering the erection of an additional grain elevator at Port Arthur, Texas, to cost in excess of $500,000 with equipment.

The Great Northern Railway is contemplating the construction of a tie treating plant at Hillyard, Wash., to cost approximately $425,000, the work to be done by company forces.

The New York, New Haven & Hartford Railroad has plans for an addition to the car repair shops at its Lamberton Street yard, to cost approximately $32,000.

The Chicago, Milwaukee & St. Paul Railway will construct a one-story frame steam power plant and a ten-stall engine house at Channing, Mich., to cost $60,000.

The Baltimore & Ohio Railroad has awarded a contract to the Bates & Rogers Construction Company, for the construction of a roundhouse and extensive trackage at Youngstown, Ohio.

The Atchison, Topeka & Santa Fe Railway has awarded a contract for the construction of a one-story steam operated powerhouse at Bakersfield, Calif., to cost $65,000.

The Boston & Maine Railroad has awarded a contract to the Dwight P. Robinson Company for the construction of a boiler shop as an addition to the locomotive repair shop at Billerica, Mass., and for improvement and extension of a roundhouse at White River Junction, Vt.

The Chicago & Eastern Illinois Railway has awarded a contract to the Roberts & Schaefer Company, for the construction of a 400-ton reinforced concrete coaling station at Evansville, Ind.

The Chicago & North Western Railway has awarded a contract for the construction of an eight-stall brick enginehouse at Watersmeet, Mich., to cost approximately $35,000, also for the construction of an eight-stall addition to a roundhouse at Chicago, Ill.

The Chicago, Rock Island & Pacific Railway will construct a coaling station and cinder pit at Caldwell, Kans.

The Pennsylvania Railroad has awarded a contract for the construction of a 250-ton reinforced concrete and steel electrically operated coaling station at Conemaugh, Pa.

The Boston & Albany Railroad has awarded a contract for the construction of an enginehouse at Framingham, Mass.

The Fort Worth & Denver City Railway has awarded a contract for the construction of a five-stall roundhouse at Amarillo, Texas, to cost $30,000.

Items of Personal Interest

W. H. Flynn has been appointed general superintendent motive power, New York Central Railroad, with headquarters at New York City. **R. M. Brown** has been appointed superintendent motive power, New York Central Railroad and Ottawa & New York Railway, with headquarters at New York, and **M. W. Hassett** has been appointed assistant superintendent motive power, with headquarters at New York.

C. S. Jones, master mechanic of the Peninsula division of the Chicago & North Western Railway, with headquarters at Escanaba, Mich., has been transferred to the Galena division, with headquarters at Chicago, Ill.

F. G. Toates has been appointed road foreman of engines, San Joaquin division of the Southern Pacific, with headquarters at Bakerfield, Calif., to succeed **S. H. Bray**, who has been promoted.

Charles H. English has been appointed superintendent of the Central division of the Central Railroad of New Jersey, with headquarters at Jersey City, to succeed **A. D. Edgar**, who has resigned. **A. R. Young** has been appointed assistant superintendent of the Central division.

O. A. Garber, formerly assistant chief mechanical officer Missouri Pacific Lines, has been promoted to chief mechanical officer, to fill the vacancy made by the death of **W. H. Fetner**. Mr. Garber was appointed assistant chief mechanical officer September 1, 1926.

J. C. Stump, general foreman of the Chicago & North Western Railway, has been appointed master mechanic of the Peninsula division, with headquarters at Escanaba, Mich., succeeding **C. S. Jones**, transferred.

W. A. Langlands, general foreman of the Galena division, with headquarters at Chicago, has been promoted to master mechanic of the Chicago terminal, with the same headquarters, to succeed **W. R. Smith**, deceased.

Bernard R. Tolson, chief clerk of the Washington Terminal Company, Washington, D. C., has been appointed manager of this company, succeeding **J. H. Tonge**, deceased.

Harry H. Shepard has resigned as general superintendent of the Delaware, Lackawanna & Western Railroad, with headquarters at Scranton, Pa., and has been elected vice-president and general manager of the Brooklyn Eastern District Terminal, with headquarters at Brooklyn, N. Y.

H. J. Bogardus has been appointed division engineer on the Port Huron Grand Rapids division of the Perre Marquette Railway, with headquarters at Saginaw, Mich., to succeed **J. E. Johnson**, deceased.

D. R. Rodgers, formerly office manager to the chief mechanical officer Missouri Pacific Lines, has been appointed assistant to the chief mechanical officer, with headquarters at St. Louis.

T. W. Love, formerly road foreman of engines, has been appointed trainmaster of the Wagoner district of the Central division, with headquarters at Van Buren, Ark., to succeed **S. E. Willis**, deceased.

G. D. Brooke, assistant to **R. N. Begien**, vice-president in charge of operation, Chesapeake & Ohio, has been appointed general manager, and **A. T. Lowmaster**, superintendent of transportation, has been made general superintendent of transportation.

L. A. Grubbs has been appointed superintendent of the Clifton Forge division of the Chesapeake & Ohio Railway, with headquarters at Clifton Forge, Va., to succeed **J. F. Briant**, who has been transferred.

Fred F. Phillips has been appointed acting superintendent special service of the Atchison, Topeka & Santa Fe Railway, to succeed **Cade Selvy**, who has retired.

I. W. Geer, assistant general manager of the Western region of the Pennsylvania Railroad, has been appointed assistant chief engineer, with headquarters at Chicago, Ill.

A. F. Judd, assistant superintendent of the Gulf Coast Lines, with headquarters at DeQuincy, La., has been promoted to superintendent of the Houston division of the International Great Northern Railroad, with headquarters at Houston, Tex., succeeding **J. E. Callanhan**, deceased.

Paca Oberlin, a member of the staff of examiners of the Interestate Commerce Commission, has resigned to become assistant to the vice-president of the Erie Railroad, with headquarters at New York City.

H. R. Lake, acting superintendent of transportation of the Atchison, Topeka & Santa Fe Railway, with headquarters at Chicago, has been promoted to superintendent of transportation, with the same headquarters.

J. B. Parrish, general manager of the Chesapeake & Ohio Railway, with headquarters at Richmond, Va., has been appointed assistant vice-president, with the same headquarters.

Elisha Lee, vice-president in charge of operation of the Pennsylvania Railroad, with headquarters at Philadelphia, has been appointed vice-president, with the same headquarters, a newly created position. **M. W. Clement**, assistant vice-president in charge of operation at Philadelphia, has succeeded Mr. Lee as vice-president in charge of operation. **R. V. Massey** has been promoted to assistant vice-president in charge of personnel, a newly created position, with the same headquarters.

M. D. Young, supervisor of safety of the Lehigh Valley Railroad, with headquarters at Buffalo, New York, has resigned. He will be succeeded by **W. E. Berger**, chief clerk to the superintendent at Buffalo.

L. G. Morphy, chief engineer of the Rutland Railroad, with headquarters at Rutland, Vt., has been appointed general superintendent, with the same headquarters. He will continue to act as chief engineer in addition to his new duties.

E. J. Ball, acting superintendent of shops of the New York, New Haven & Hartford Railroad, with headquarters at Van Nest, New York, has been appointed superintendent of shops, with the same headquarters.

H. M. Williams has been appointed safety instructor of the Missouri Pacific Railroad, with headquarters at St. Louis, Mo.

G. L. R. French, general manager of the Rutland Railroad, with headquarters at Rutland, Vt., has been appointed assistant vice-president and general manager, with the same headquarters.

Supply Trade Notes

Merrill C. Morrow, formerly assistant to the general manager of the merchandising department of **Westinghouse Electric & Manufacturing Company**, has been appointed assistant sales manager of that department. In his new position his headquarters will be at the company's Mansfield, Ohio, plant.

Victor Larson is to be in charge of the new office of **Arthur Jackson**, Toronto factory representative for a number of machine tool manufacturers in the United States, his headquarters will be located at 437 Grosvenor avenue, Westmount, Montreal. Mr. Larson was formerly production manager for the **Canadian Ingersoll-Rand Company.**

The Davis Brake Beam Company has discontinued its Roanoke office, and in the future the business of that territory will be handled by the general office at Pittsburgh, Pa.

Walter M. Flanagan, who has been steam engineer in the Youngstown district for the **Carnegie Steel Company** for eight years, has been added to the staff of the chief mechanical engineer of the company at Pittsburgh, Pa.

The Whiting Corporation of Harvey, Ill., announces the following changes in its personnel. **R. E. Prussing**, for many years district sales manager at Detroit, has taken up duties at the main office at Harvey. Mr. Prussing is succeeded by **W. N. Hans**, district manager at Buffalo. Sales in the Buffalo district will be handled hereafter by **C. G. Crewson.**

The American Brown Boveri Electric Corporation, Camden, N. J., announces that it now has four district offices, situated at 165 Broadway, New York; 230 South Clark street, Chicago, Ill.; 842 Summer street, Boston, Mass., and 922 Witherspoon building, Philadelphia, Pa.

The **Homestead Valve Manufacturing Company** has opened a branch office at 310 Union Mortgage building, Cleveland. **F. W. Layman** is to be in charge of the Akron-Cleveland district. Mr. Layman has been connected with various departments of the company and during the past few years covered the territory in the southwestern and far western states and in Canada.

L. S. Harding, who has been employment manager and director of training for the **Worthington Pump & Machinery Corporation**, East Cambrige, Mass., for several years, has been appointed industrial training advisor for the **Associated Industries of Massachusetts.** In addition to assuming his new duties he will continue his activities with the Worthington Pump & Machinery Corporation.

A. O. Norton, Inc., opened for operation at Moline, Ill., a new plant for the manufacture of Norton Jacks. All models will be manufactured at the new plant, which eventually will become the main manufacturing plant.

Owen R. Rice has resigned as assisant blast furnace superintendent of the Maryland plant, **Bethlehem Steel Corporation**, to become associated with the **Freyn Engineering Company** of Chicago, Ill.

Carl G. Schluderberg has been appointed general manager of the **George Cutter Company**, South Bend, Ind., a subsidiary of the **Westinghouse Electric & Manufacturing Company**

F. R. Pfaff, assistant advertising manager of **Albert Pick & Company**, has been appointed advertising manager of the **Independent Pneumatic Tool Company**, Chicago, to succeed **Frank F. Leavenworth**, resigned.

The Cleveland officers of the **Central Alloy Steel Corporation** and the **United Alloy Steel Corporation** have been combined and moved to 1716 Union Trust building.

Frank L. Gibbons, who has been Cleveland district sales manager of the **Central Steel Company**, Massillon, Ohio, has been appointed Cleveland district sales manager of the **Central Alloy Steel Corporation.**

F. P. Fairchild has been appointed engineering manager for the **Ladd Water Tube Boiler Company** of Pittsburgh. Mr. Fairchild formerly was power engineer in charge of design on steam power developments for **Dwight P. Robinson & Co.**

P. Roberts Baker, manager of operations at the Coatesville plant of the **Luken Steel Company**, has been appointed assistant to the president. A new position, that of general superintendent, has been filled by the appointment of **William H. Warren**, who has been general superintendent of the **Trumbull Steel Company.**

Charles E. Sampson has been appointed service engineer for the **National Safety Appliance Company.**

John R. Blair has been appointed manager of sales of the **Pittsburgh Steel Products Company**, Pittsburgh, to succeed **Charles F. Palmer**, who has resigned. Mr. Blair has been associated for the past eight years with the sales department of the company and its predecessor, the **Seamless Tube Company of America**, and for several years has been acting as assistant to the general manager of sales.

The American Brake Shoe & Foundry Company announces the formation of a new subsidiary, the **American Brake Materials Corporation**, for the manufacture of a new friction element for automobile vehicles, known as **"American Brakebloks."**

H. W. Dillon, formerly with **Durant & Company** of New York, has been made Philadelphia sales manager of the **Chicago Pneumatic Tool Company**, New York.

The Chicago Pneumatic Tool Company has established a sales and service branch in the Mills building, El Paso, Texas. **E. J. Coughlin** is in charge of the branch.

Leland Brooks, formerly vice-president and treasurer of the **Franklin Railway Supply Company, Ltd.**, Montreal, has been appointed special representative of the **Worthington Pump & Machinery Corporation**, with headquarters at Chicago. In addition to other duties Mr. Brooks will handle the railroad sales in Canada.

H. E. Graham has been appointed an assistant vice-president of the **American Car & Foundry Company** and will be associated with the sales department, with headquarters at New York. Mr. Graham was formerly connected with the **Pressed Steel Car Company** and later was vice-president in charge of sales of the **Standard Tank Car Company.**

R. C. Brower of the Automotive and Industrial Machinery sales division of the **Timken Roller Bearing Service & Sales Company** has been promoted to general manager, with headquarters at Canton, Ohio.

Bruce Owens, sales manager of the **Magnus Company, Inc.**, with headquarters at Chicago, has resigned to become vice-president of the **O'Malley Beare Valve Corporation**, with headquarters at Chicago.

Lauren J. Drake, president of the **Galena Signal Oil Company**, has been elected president of the **Union Tank Car Company**, with headquarters at Chicago, to succeed **E. C. Sicardi**, retired. **H. E. Felton** remains chairman of the board of directors.

The Westinghouse Electric & Manufacturing Company has necessitated the reorganization of the general engineering department of that concern. The engineers promoted are **F. C. Hanker**, manager of central station engineering; **S. B. Cooper**, manager of railway engineering; **G. E. Stoltz**, manager of industrial engineering, and **W. E. Thau**, manager of marine engineering. **S. A. Staege**, formerly section engineer in charge of the paper mill section, has been appointed industrial engineer. Other appointments announced by **H. W. Cole**, assistant director of engineering, are: Central station engineering, **C. A. Powel**, engineer, generating station engineering; **R. D. Evans**, engineer, transmission engineering, and **C. A. Butcher**, engineer, substation engineering. In the railway engineering division **H. K. Smith** has been appointed engineer, heavy traction engineering; **G. M. Woods**, engineer, light traction engineering, and **A. H. Candee**, engineer, gas-electric traction engineering.

Obituary

Edward W. Grice, assistant to the president of the Chesapeake & Ohio Railway, with headquarters at Richmond, Va., died on September 29, 1926. Mr. Grice entered service 1880, since which he has been consecutively to 1882, telegraph operator of Wabash, St. Louis & Pacific Railway. From 1882 to 1885, he served consecutively as a freight clerk and train dispatcher, and from 1885 to 1888, chief train dispatcher for the Louisville, Evansville and St. Louis Railroad. From 1889 to 1890, chief train dispatcher with the Pittsburgh & Western Railroad. In 1890 he went to Chesapeake & Ohio Railway as chief train dispatcher, which position he held until he was promoted to trainmaster in 1898. In 1901 he was promoted to division superintendent, Clifton Forge division, with headquarters at Clifton Forge, Va. In 1906 he was promoted to general superintendent, with headquarters at Hinton, West Va., which he held until 1910, when he was promoted to general manager. In July, 1912, he was appointed assistant to the fourth vice-president of the Chesapeake & Ohio and Hocking Valley Railways, which he held until 1915, when he was appointed assistant to the president of the Chesapeake & Ohio Railway, which position he held until his death.

Nicholas B. Trist, special wheel engineer for the Carnegie Steel Company, died at his home in Sewickley, Pa., on September 29. Mr. Trist entered the service of the Pennsylvania Railroad in 1862 as an apprentice in the Altoona shops and served with that road in various capacities until 1885, when he then became connected with the Schoen Steel Wheel Company, and in 1908, when that firm was taken over by the Carnegie Steel Company, became associated with the company.

William J. Watson, organizer of the Buda Foundry & Manufacturing Company, the Hewitt Manufacturing Company and the Fort Madison Iron Works, died in Chicago on October 1. He was born on March 26, 1843, in Philadelphia, entered business in 1863 and in 1870 was appointed a representative of the Middleton Car Spring Company, with headquarters at St. Louis, Mo. He was transferred to Chicago and was elected president in 1890. He organized the Buda Foundry & Manufacturing Company in 1884, the Hewitt Manufacturing Company in 1886 and the Fort Madison Iron Works in 1887, serving as president of these corporations.

New Publications

Books, Bulletins, Catalogues, Etc.

Around the World with Westinghouse is the title of a 20-page publication recently released by the Westinghouse Electric & Manufacturing Company containing reproductions of a series of advertisement which appeared in the technical press, describing Westinghouse railroad electrification achievements in the various countries of the world. Each advertisement was devoted exclusively to one country, emphasizing the primary object for electrifying. Illustrations of the type of electric motive power used together with characteristic views of the subject country typify each advertisement.

A tabulation of Westinghouse equipped electric motive power units in service throughout the world, giving such data as voltage of system, weight, ratings, years in service, and similar table of multiple unit cars are included in the publication.

Copies of this publication, S. P. 1755, may be obtained free of charge from the nearest Westinghouse office or from the Transportation Section, Department of Publicity at East Pittsburgh, Pa.

Modern Yard Operation.—The Union Switch & Signal Company has issued a book which explains the installation and operation of car retarder systems in hump yards. Some data are incorporated, showing that an existing installation of car retarders is effecting a saving on the investment. An engineering explanation of the grades required for retarder hump yards is then given, followed by directions for training operation. A chapter is devoted to the electro pneumatic car retarder system, including an outline of the principal items to be considered in making estimates for such work. Another section is devoted to an extensive description of the installation car retarder system in service in the Markham yard of the Illinois Central Railroad. The other chapters contain preliminary studies, engineering features, mechanical facilities, communication system, signaling, yard lighting and operating methods. Several typical plans and data make this book a complete text book on the subject. Copies may be obtained from the general offices of the company.

Accident Prevention on a Railroad.—The Metropolitan Life Insurance Company, New York, has issued a booklet which contains the story of an accident prevention. It also illustrates the methods used in making study and the type of information deemed essential. An outline for the safety of railroad employee is also included. Copies of the booklet may be obtained free of charge from the general offices of the company located at 1 Madison avenue, New York.

Tool Steel Handbook.—The Ludlum Steel Company, Watervliet, N. Y., has just released the second edition of its Tool Steel Handbook, describing in detail carbon, alloy, rust and heat treating and their methods. Copies of the book may be obtained free of charge from the general office of the company at Watervliet, N. Y.

Superheater Steam Pyrometers.—The Superheater Company, 17 East Forty-second street, New York, has issued the third edition of the instruction book on superheated steam pyrometers which contain instructions for the installation, operation and maintenance of the pyrometer model 496, and a convenient list of parts are given in the rear of the book. Copies of the book may be obtained from the company at 17 East Forty-second street, New York.

General Catalogue No. 20.—The Ohio Brass Company, Mansfield, Ohio, is distributing this book free, which includes a complete listing of all O. B. porcelain insulators, trolley and line materials, rail bonds, car equipment and mining materials. It is divided logically, and has a marginal thumb index for the well defined grouping of the products manufactured by this company. Signal bonds and other special products of interest to the signal departments of steam railroads are in one section, and there is a listing of automatic car couplers, including electric and air connections. Copies of the book may be obtained free of charge from the general offices of the company at Mansfield, Ohio.

Stainless Steel and Stainless Iron.—Booklet No. 113, which has been issued by the Bethlehem Steel Company, Bethlehem, Pa., contains working instruction for Bethlehem stainless steel forging and stainless iron forging. These metals can be rolled forged, pressed and hammered, and can be used for machinery parts, especially those subjected to corrosion. Copies of the booklet may be obtained at any of the district offices of the Bethlehem Steel Company.

Railway and Locomotive Engineering

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Roller Bearing Equipment on the St. Paul

Practicability of Anti-friction Bearing for Passenger Equipment Demonstrated in Tests Extending Over Two Years

The Chicago, Milwaukee & St. Paul Railway recently ordered 64 Pullman cars and 63 passenger cars to be equipped with roller bearings, following rather exhaustive tests conducted over a period of two years of bearings made by the Hyatt Roller Bearing Company, the S. K. F. Bearing Company and the Timken Roller Bearing Company. While satisfactory results were obtained with all the bearings tested, the order was finally placed with the Timken Roller Bearing Company.

All Steel Passenger Equipped with Roller Bearings on the Chicago, Milwaukee & St. Paul Railway

In a paper read at the annual staff meeting of the car department of the Chicago, Milwaukee & St. Paul, L. K. Sillcox, general superintendent of motive power, summarized the experience of that road in testing roller bearing equipment as compared with cars having the usual type of plain bearing as follows:

While roller bearings have been discussed and considered for steam railway service during a period of almost 25 years, the missing quality has always been that of durability, and designers of such bearings, in their efforts to produce something suitable, apparently erred on the side of giving the mechanics of the subject too much attention. They seemed to be interested chiefly in obtaining large contact areas, and in their endeavor along these lines, unfortunately neglected many other essentials, which were necessary in the development of this heavy type of bearing.

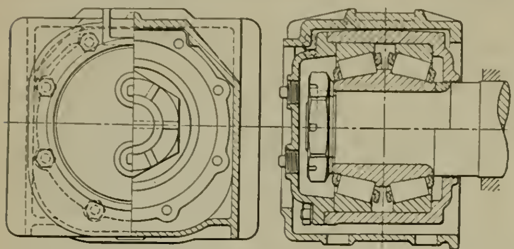
Eventually, it was realized that it was not sufficient to state simply that a bearing dealt with so many pound load at a certain speed. This statement required qualification in that the fatigue resisting properties would have to be defined, coupled with the need for taking up, for absorbing and directing, elements of side thrust under very difficult conditions of load and speed, as well as the load carrying capacity. Where the loads were high, but the speed low, the problem could always be solved by means of a ball type bearing, but there were certain limits to speeds and loads which, taken together, formed a serious obstacle to the use of antifriction bearings such as known in the past.

On account of the difficulty in arriving at a conclusion concerning fatigue, from a mathematical standpoint, and from the basic considerations previously laid down, it came to be recognized that this aspect of the subject could only be determined by reference to the most extensive range of experiments, and to available data regarding bearings which had been operating under prevailing conditions; those being almost exclusively of the ordinary, or plain type, such as we have employed. This led to the fact, however, that ball bearings could certainly deal with heavy loads at comparatively high speeds, but such bearings would have to be of dimensions which were quite impracticable in many cases, and necessitated redesign of truck frames and associated parts in order to accommodate the new construction which, together with the cost of the

bearing, which of course, was much higher than that of a plain bearing—had to take into account new truck construction. Thus the problem has, until very recently, appeared insurmountable from a financial standpoint.

A roller bearing was developed that would take the standard type truck construction. This was worked out with the assistance of the S K F engineers, the final result being an assembly as shown in the photograph and drawing. A standard cast steel truck frame was used and the only change which had to be brought about was that of applying straight equalizers rather than the curved ones as in the past.

It will be observed that in the design of the cast steel pedestals, the pedestal legs were shortned to accommodate the new type box, and made considerably stiffer to eliminate the necessity of using a tie bar between them, sufficient rigidity being obtained to take care of the longitudinal thrust to which they are subjected. The method of applying the journal load through the straight equalizer and below the center line on the journal box, serves to keep the box in suitable alignment through the pendulum action of the load. The journal box is of cast steel, and since it is subjected both to tensile and flexural stresses, it has its heavy section around the load carrying surface at the top, and stiffening ribs both at the top and around the bottom stirrup which carries the equalizer. The outer race of the bearing is in contact with the crown of the box through an arc of 150 degrees. A forged shoe is dropped in the bottom of the stirrup to properly center the equalizer and secure it against motion longitudinally. A safety hanger is provided between the equalizer bar and the pedestal. Manganese steel pedestal liners are employed.



Four Motion Journal Box Fitted with Timken Roller Bearing

A design was also developed using the Hyatt bearing, which operating under Coach No. 4283 and which is shown in one of the drawings. Another drawing shows the Timken roller bearing, which was developed and adopted for use on the cars recently ordered.

From the experience gained, it is our present judgment that selection of roller bearings should be made on the following basis:

1. Minimum friction.
2. Ability to deal with both thrust and radial loads.
3. Ability to deal with thrust load in one direction.
4. Ability to operate successfully for at least 1,000 miles after becoming initially defective, in order to allow a car to be brought to a terminal.
5. Ability to operate a minimum of 600,000 miles without failure of parts, wreck damage excepted.
6. The unit should be self-contained, with minimum number of loose parts, and should be nonadjustable.
7. The unit should be capable of quick inspection.
8. The unit should have the feature of self-alignment.

The ideal lubrication for an anti-friction bearing is a constantly circulating oil in an ample, but not too ample, volume and with only slight pressure.

There are five main difficulties that lie in the way of oil lubrication:

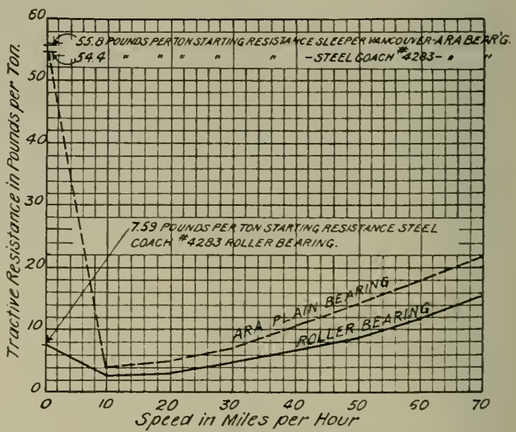
1. Heat is generated by the churning of the oil at speeds as low as 300-400 r.p.m. (32-43 m.p.h.) unless an overflow is provided to maintain a proper level: This churning and heating increases proportionately with the depth of the oil and the rate of speed.
2. Oil, being a liquid, is hard to retain in a housing. This is especially true because under the churning action of the moving rollers the oil is vaporized and is dissipated to a certain degree.
3. Owing to vaporization and other factors, oil requires renewal every six months or more.
4. When axles are not revolving, force of gravity draws the oil to the bottom of the housing, leaving the bearing dry and exposed to rust: filling housings full enough to cover the rollers at all times in the above-mentioned churning and heating.
5. Oil is more expensive than grease.

From this it may be remarked that, however proper oil lubrication might be, it is almost impossible to attain minimum rates of expense under the average service conditions.

As a result of these conditions, it is generally recommended to use grease, where possible, at all speeds and temperatures and for all sizes of bearings; this does not mean that on some applications oil will not give a satisfactory service but that a proper quality and grade of grease on these applications should give equal, if not better, service with less trouble.

This recommendation is based on the following points:

1. Grease of the proper consistency does not work out of the housing.
2. Enclosure design is simplified.
3. Grease applied with a modern type of gun is kept perfectly celan.



Resistances of Plain and Roller Bearings

4. Grease does not need as frequent renewals.
5. Grease does not sink to the bottom of the closure when the bearing is idle.
6. Suitable greases should be easy to obtain.
7. Since grease tends to fill the space between shaft and housing, it assists materially in keeping out dirt.
8. Under high speeds the rise in bearing temperature is less than with oil.

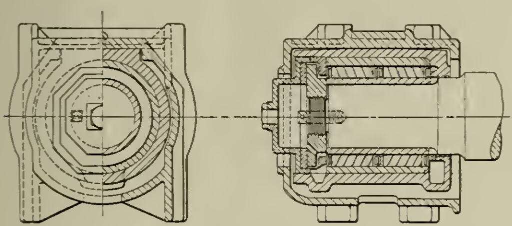
The essential properties of a suitable roller bearing grease are: (a) Consistency a little stiffer than vaseline. This is important, as a grease of this consistency is stiff

enough not to churn at high speeds, yet soft enough not to dry. (b) No abrasive or body-giving matter, such as talc, graphite or pummice. (c) Mineral base—not vegetable or animal.

For a range in speeds—300 to 840 r.p.m.—(32-90 m.p.h.)—a grease renewal once a year is said to be ample. Under any conditions the most frequent renewal is every six months.

At time of renewal the housing should be filled up until some of the old grease works out which can be wiped off. This is also a good time to note the quality of the grease last used and to see whether it has hardened. The tendency of grease to dry out is what really determines the frequency of lubrication.

While it is well known that lubrication for anti-friction bearings is not required in the same sense as for plain



Hyatt Roller Bearing Applied to Car Journal

bearings, it is not so well known that the type of lubrication, or the quantity used, may have a considerable effect on the coefficient of friction and operation of the bearings. At high speeds, if the amount of oil applied is excessive, or the viscosity unsuitable, a considerable amount of heat may be generated due to churning.

The best information we have covering a comparison of resistances of cars equipped both with roller and plain bearings is shown in the accompanying chart. Our tests indicate that with steel sleepers the starting resistance may be as high as 55.8 lbs. per ton; for steel coaches 54.4 lbs. per ton; while under the same conditions, at the same time, resistance for steel coaches fitted with roller bearings was 7.59 lbs. per ton. Under these circumstances it is possible to require in starting the Pioneer Limited, 15 cars, an effort from the locomotive of 67,200 lbs. for equipment as fitted with plain bearings, as against 9,120 lbs. required under these circumstances for equipment fitted with roller bearings—or in the ratio of approximately 7 to 1.

From available information, it is clear that general evidence points to the fact that the greater the weight per coach, the lower will be the running resistance per ton and, consequently, the proportional advantage of anti-friction bearings is greater. It also seems clear that the lower the speed, the greater the advantage to be obtained with roller bearings.

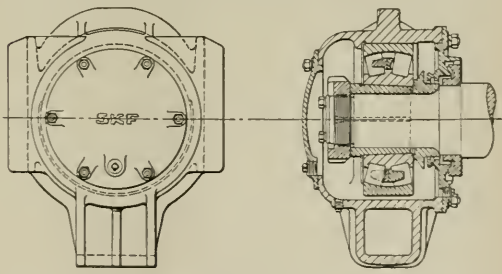
If a substantial economy in coal consumption can be achieved as has been shown in other tests, the increased cost of applying roller bearings will be returned in a period of five years, depending, of course, upon the annual mileage the cars would make. A further advantage could also be stated in the reduction of cost of lubricant, which has been referred to, to say nothing of ultimate saving in cost of journal inspection were all our trains fitted up.

It is generally considered that the principal object of adopting roller bearings is to eliminate hot boxes and reduce maintenance. However, in our case it was a matter of relieving our present locomotives of enough load so that the new equipment for the Olympian and Pioneer Limited trains could be handled with success and still heat the equipment without resorting to the use of auxiliary apparatus, which has been required in the past in cases where more than ten cars were handled. A freight engine can start whatever it can handle on the road, because freight couplers have greater end-wise movement and there is no objection to taking slack, while in passenger service a locomotive can generally handle (if the boiler is of sufficient capacity) whatever it can readily start. Our trains are extraordinarily heavy, considering the motive power we employ, and the difficulty with us is in starting without rough handling. It is considered that if the application of roller bearings will enable us to start our trains more easily then it is a good investment, because once the train is on its way there is no difficulty keeping it moving at the required speed, where a suitable supply of steam is furnished the cylinders.

Granting that anti-friction bearings of any type will greatly reduce starting resistance, their influence in normal running speeds is highly debatable. There is a saving, but it is not large. Granted the reduction in starting resistance that any good anti-friction bearing will make possible, the question then becomes, in my opinion, one of life and cost thereof. The utilization of the reduction in starting effort ought to bring about an entire change in motive power economics, but this will be a slow development with a good deal of resistance to be overcome.

Those who have used roller bearings most extensively have been so satisfied with the practical results that they have thus far not been disposed to attempt to compare train resistance data through such elaborate tests as would be necessary therefore. They have only sought to confirm the known starting economy of roller bearings.

One of the principal difficulties encountered in attempting to evaluate the decrease in train resistance, due to the use of roller bearings, is the lack of a definite standard for comparison in the form of data representative of standard friction bearing equipment. There is no question but that the variation in the friction of the plain journal bearing is an important factor and tests have been made to show the effect of journal temperature on train resistance.



S. K. F. Roller Bearing Applied to Car Journal

Whatever figures have been made, make it apparent that the actual train resistance of plain bearing equipment is very indefinite except in terms of general averages interpreted as representative of normal conditions. On the other hand, our experience with anti-friction bearings has shown that the friction of the bearing is constant over a very wide range of speed and temperature conditions.

The inherent characteristics of the two types of bearings justify certain inferences. It is known that the efficiency of the plain bearings is determined by the factors that control the establishment of the oil film. These include both temperature and speed, which are obviously variable in train operation, and is also dependent on unit pressures which will vary with type of equipment. The resistance of the roller bearing is practically independent

of temperature and speed, through such range as is experienced in train operation. Analyzing exhaustive tests on plain bearings which are comparable with those employed on car journals, indicates that only under most favorable conditions will the friction in a standard plain bearing compare favorably with that uniformly experienced with the roller journal bearing. Practical limitations preclude the normal operation of plain bearings under those favorable conditions, since the low viscosity of oil required, does not provide a sufficient margin against sudden incidental effects, which would lead to a further decrease in viscosity with loss of oil film and seizure of the bearing. It is, therefore, apparent that the normal operation of plain bearings is under conditions which imply a higher friction than that which obtains in roller bearings.

With reference to the question of starting resistances, it is difficult to give a very definite commitment, even though experience figures are here stated. When a train starts, say, in the morning, after having been standing for some time, the plain bearing journal friction may be a fairly high percentage of the total effort required in starting and certainly, in this case, an advantage in easier starting is obtained by the roller bearing—some assuming a 50 per cent reduction. The value of reduction of friction obtained in this way means greater acceleration. For local runs where stops are frequent, the plain journal resistance would certainly be higher after each stop, and the effect of this is to give a varied resistance depending upon the time in operation and the length of the stop.

In referring to test carried on by the University of Illinois with plain bearing cars, it is noted that the starting resistance is about seven pounds, and at the end of the first stretch this drops to about 4¼ pounds per ton. In starting away again the resistance rose 7½ pounds per ton, and in the next stretch dropped to 4½ pounds per ton. In starting off again the resistance was increased to a little over 5 pounds per ton, and this dropped to 3½ pounds per ton. It can be well appreciated, if a severe grade has to be faced immediately after the first stop, the journal resistance will have a very considerable effect on the work required of the locomotive to be expended in getting the train under way.

One last consideration has to do with the importance of providing suitable hand brakes, buffers and draft gears (no preliminary spring action required as at present to aid in starting trains). These items are matters of experience, but need to be anticipated while dealing with this problem. The advantages to be gained from drifting trains are quickly apparent and should be studied in service with a view to relieving the engine and consequently the coal pile to the greatest extent.

Largest Storage Battery Locomotive

What is claimed to be the largest storage battery locomotive in the world, weighing 110 tons and capable of hauling a 1,500-ton train, equivalent to 70 empty or 30 loaded freight cars, at a speed of from 8 to 10 miles an hour, is now in service in Chicago. Pulling a passenger coach, carrying railroad engineers and officials as well as representatives of the General Electric and Electric Storage Battery Companies, designers and manufacturers of the locomotive, it made the 450-mile trip from the Erie, Pa., works of the General Electric Company under its own power, with a stop at Cleveland for exhibition at the American Electric Railway convention.

This unit has many of the advantages of the usual electric locomotive without requiring an overhead trolley or third rail for its source of power. It will be used for some time in the freight yards of the Chicago and Northwestern Railway to demonstrate its possibilities in solving some of the problems of railroad terminal electrification in that city. The locomotive, incorporating features of both the storage battery and the gas-electric drive, has a number of novel features which make it particularly adaptable to switching service.

New Type of Air Brake Instruction Car on Union Pacific System

An air brake instruction car unique in several particulars has been completed in the Los Angeles Shops of the Union Pacific.

An old 78 ft. observation car was used. The body was strengthened by the addition of four truss rods, and six wheel trucks, and special springs to carry the increased weight.

In the car have been installed 75 sets of freight brake equipments with 43 feet of 1½ inch, and 6 ft. of 1 inch brake pipe per set, the equivalent of 75 car train. Of the sets, 60 are 10 inch and 15 are 8 inch equipments. Standard "K" triple valve were used on all but eight which where equipped with the old style quick action valve so as to demonstrate the advantages of the "K" valve.

There are installed six sets of passenger equipment, two single PM, two single LN, one double cylinder UC and one single cylinder UC of the quick service type.

One operative automatic slack adjuster was installed and all reservoirs and other demonstrative apparatus is inside the car. A 14 passenger car signal line equipment is represented by fourteen 63 foot lengths of pipe with cutout cocks and hose; also several car discharge valves. Some idea of the compactness of the car can be had when it is considered that about 3,564 feet of 1¾ inch, 600 feet of 1 inch and about 882 feet of ¾-inch pipe have been installed without objectional bends, and still ample window space for lighting and ventilation is provided. Comfortable seating capacity is provided for fifty people.

At the end of the car a complete set of locomotive air brake operating details, including two driver and one tender brake cylinder have been installed. Passenger or freight equipment may be operated from the one locomotive equipment by opening one cutout cock and closing another.

The regular locomotive air gauges, two single pointer gauge with 12 inch dial is used, one showing brake pressure at head and the other at the rear of train. This calculated to bring out the time interval as between the head and rear positions of the train, during the release operation. The piping is provided with extra cutout and drain cocks, so that the effect of leakage can be shown.

Gauges have been provided on the reservoir and brake cylinder of about 20 freight equipments, so as to show the effect of unequal piston travel. Gauges have also been provided on enough of the reservoirs and brake cylinders to clearly show that action of these equipments.

Tables will support various sectional apparatus, such as the air brake operating details, injectors, lubricators, power reverse gear, etc.

The car was equipped completely in the car shop at Los Angeles, Calif. The air brake details and piping were engineered by V. Villotte of the Westinghouse Air Brake Company.

The car is intended primarily for service on the Los Angeles & Salt Lake division of the Union Pacific System. It is intended to have as many road engineers and firemen as possible examined in the car on the handling of air, as rapidly as they can take the examinations.

C. M. Freeman who was recently appointed air brake instructor with headquarters at Los Angeles, Calif., is in immediate charge of the car.

Mountain Type Locomotives for the Pennsylvania Railroad

Designed for Heavy Passenger and Fast Freight Service

In 1923 the Pennsylvania Railroad built, at its Juniata Shops, Altoona, a Mountain (4-8-2) type locomotive which was notable because of its high capacity and interesting constructive details. In accordance with the Pennsylvania's policy, this locomotive was subjected to a series of exacting tests, on both the road and the stationary plant, before any additional units of the same class were ordered. After the locomotive had proved itself fitted for the service requirements, orders were placed with the Baldwin Locomotive Works for 175, and with the Lima Locomotive Works for 25 additional locomotives of the same type. These locomotives are designated by the Railroad Company as Class M 1, and are now being placed in service. They were designed by the Motive Power Department of the Pennsylvania under the supervision of J. T. Wallis, Chief of Motive Power. They are intended for heavy passenger service, for which reason the driving wheels are 72 inches in diameter, but will also be used for fast freight service, for which the high draw-bar pull makes them suitable.

Mountain or 4-8-2 Type Locomotive of the Pennsylvania Railroad Built by Baldwin Locomotive Works

Class M 1 develops a starting tractive force of 64,550 pounds; and with 266,500 pounds on driving wheels, the ratio of adhesion is 4.13. This high starting power, in combination with a boiler of generous steaming capacity, enables these locomotives to develop large horse power for sustained periods.

In accordance with the Pennsylvania Railroad's practice, the boiler of Class M 1 is of the Belpaire type, with tubes of moderate length (19 feet between tube sheets). Exclusive of the smokestack, the cylindrical section of the boiler consists of two rings, the first of which is sloped, increasing the shell diameter from 84½ inches to 96 inches. The dome is placed on the second ring. It is of pressed steel, and measures 31 inches in diameter and 13 inches in height. The longitudinal seam on this ring is placed on the right hand side, and after the sheet has been rolled to a circular shape, it is flanged on top to form the hip joint connection for the Belpaire firebox.

The combustion chamber in the boiler is 8 feet 2 inches long, and this necessitates the use of a wrapper or outside shell section of corresponding length, having Belpaire shape and staying. This combustion chamber section of the outside shell is made up of four pieces, viz:—a bottom half, which is in one piece with the outside throat sheet; two side pieces; and a top piece. The radius of the throat is unusually large, being 16 inches at the center, reducing to a smaller radius at the sides. The outside firebox shell is of three-piece construction, the top and sides being separate.

The crown and sides of the inside firebox are in one piece, and the inside throat sheet is in one piece with the lower half of the combustion chamber. The sides and crown of the combustion chamber constitute a separate sheet, which is butt-welded to the lower sheet on each side. The firebox and combustion chamber are united above the welded longitudinal seam by a corrugated plate which constitutes an expansion joint. This plate has riveted seams, except on the short longitudinal side seams which are welded. The corrugation is made with a two-inch radius, and forms a trough about five inches deep across the crown sheet. This trough can be cleaned through two wash-out holes, one of which is placed on each side.

The flanging of this corrugated sheet is done on a hydraulic press, and is an interesting process. As the transverse width of the sheet, after flanging, is greater at mid-height than at either the top or bottom, the sides of the die are hinged, so that they can be collapsed after flanging and the plate thus lifted out. The flanging of the throat sheets also requires special treatment, due to the large size of the plates and the fact that the radius at the center is considerably greater than at the sides.

The corrugated joint described above compensates for expansion and contraction in the upper part of the firebox. To make similar provision for the lower part of the firebox, a crescent shaped corrugation is formed in the front tube sheet, below the tubes. This corrugation has a maximum depth, at the center, of two inches. The combined length of firebox and combustion chamber is so great, in this design, that an arrangement such as has been described is desirable in order to prevent distortion and tube leakage.

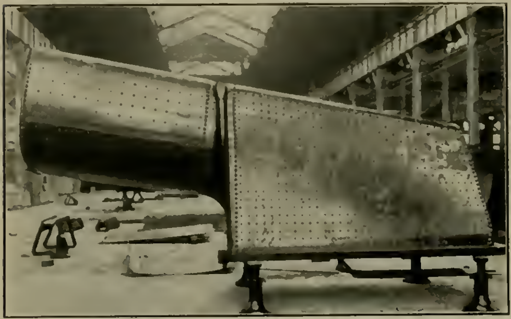
The firebox tube sheet and back sheet are riveted in place, but the joint around the door sheet is electrically welded. The flues are welded into the back tube sheet.

These locomotives are fired by mechanical stokers, the Duplex and the du Pont-Simplex each being used on 100 engines. The grates are arranged to shake by hand, and have transverse drop plates near the front of the firebox The ash pan has two deep hoppers, which are fitted with drop bottoms. These are controlled by levers placed on the left-hand side, under the front end of the firebox.

The two injectors are non-lifting, and they feed through checks placed on the back boiler-head. The feed water is conveyed to the front end of the barrel through internal

pipes, this arrangement being in accordance with the regular practice of the Pennsylvania Railroad. The steam turret is placed outside the cab, and receives its steam supply from the highest point in the boiler through an external pipe which connects to the shell near the front end of the combustion chamber roof sheet. The two safety valves are tapped directly into the shell, just forward of the steam turret connection.

In addition to the usual gauge cocks which are tapped into a water column on the back head of the boiler, there is a second set having pipe connections which terminate over the highest part of the crown sheet. These pipe connections are run through an external pipe which is filled



Firebox and Combustion Chamber Showing Expansion Joint

with steam, so that condensation is avoided. These gauge cocks are placed over the boiler head in the cab. They have extension handles, conveniently located, and drain into the drip funnel, so that the discharge can be easily seen by the engine man.

The dome contains a throttle valve with a balancing piston, from which steam passes to the superheater header through an internal dry pipe, 8½ inches in diameter. The superheater is a "type E," composed of 170 single loop elements placed in as many 3½-inch flues. The steam distribution is controlled by 12-inch piston valves which are operated by Walschaerts gear, and are set with a travel of 7 inches and a lead of 9/32-inch. The steam lap is 1 7/16 inches and the exhaust clearance 7/16-inch. A power reverse mechanism is applied.

The machinery details follow Pennsylvania Railroad standard practice, which aims at reducing the weight of the parts as far as is consistent with safety, by the use of heat treatment, and careful designing. The crossheads are of the underhung type, working in box shaped guides which have two inwardly projecting longitudinal ribs on each side in order to provide liberal bearing area. Each guide is made in two pieces, which join on the longitudinal center line and are held together by horizontal bolts. The crosshead bodies are of high test Vanadium steel; while the crosshead pins, piston rods, crank pins and driving axles are of heat treated carbon steel, and hollow bored. The main and side rods are also heat treated. Floating bushings are used on the main rod back ends and the main pin bearings on the side rods. Each stub has a horizontal cavity closed by a compression grease plug, and communicating with holes drilled through the brass, so that the pin can be lubricated.

The main frames are unusually massive, as the width, throughout the greater part of their length, is 7 inches. This is increased above the pedestals, to 9½ inches by inwardly projecting lugs. Each frame is cast in one piece with a single front rail having a cylinder fit 6½ inches wide and 12 inches deep. The pedestal caps are of ample section, and are held in place by three bolts on each end. Back of the rear driving pedestals, the frames assume the form of slabs, and are bolted to a Commonwealth cradle casting. The pedestal taper is 1½ in 18½ inches.

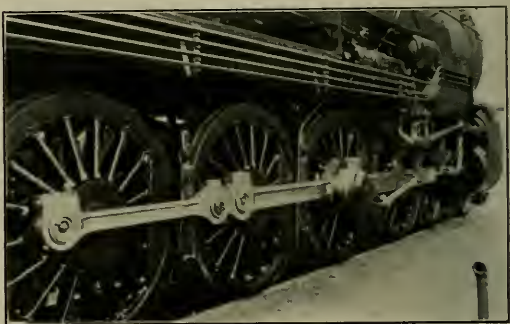
These frames are braced transversely, mid-way between adjacent driving axles, by steel castings which are bolted to both the upper and lower frame rails. Intermediate boiler supports, in the form of expansion plates, are provided at the guide yoke, which is just ahead of the leading drivers, and also between the second and third pairs of drivers. The front end of the firebox is carried on sliding bearings, and the rear end on an expansion plate.

The front truck is of the swing bolster pattern with three-point suspension links, while the rear truck is similar to that used on the Atlantic, Pacific and Mikado type locomotives of the Pennsylvania and formerly known as the "K W" type. In this design the truck frame itself acts as the rear equalizer, and the main locomotive frames are supported directly on it.

In accordance with the railroad company's practice, the driving and rear truck springs are made with a reverse camber when loaded, the flanged tires are used on the front and rear driving wheels only.

Among the interesting details used on these locomotives may be mentioned the bell ringer, which is air operated. When the device is in use, the bell itself remains stationary, while the clapper moves. The bell can also be rung by hand in the usual way, if necessary. The cylinder cocks are steam operated, and are controlled from the cab. When the operating valve is open the cocks are closed by steam pressure acting on their plungers. When the steam pressure is released, the plungers are moved upward by spring pressure, and the cocks open. This provides a ready means of keeping the cylinders drained while the locomotive is standing. The cylinder cocks will also be open in case the pressure in the cylinders exceeds the boiler pressure due to water being trapped in the cylinders.

The tender has a one-piece frame of cast steel, and is



Driving Wheels and Running Gear

carried on two four-wheel trucks having cast steel side frames. The fuel and water capacities are respectively 35,000 pounds and 11,000 gallons, and an air-operated water scoop is applied.

The Locomotive is equipped with superheater, stoker, power reverse, and air brake on all driving, front and back engine truck, and tender wheels, with one 8½" cross-compound pump.

The principal dimensions of these interesting locomotives are given in the accompanying table.

Gauge	4 ft. 8½ ins.
Cylinders	27 ins. x 30 ins.
Valves	Piston, 12 ins. diam.

BOILER

Type	Wagon top
Diameter	84½ ins.
Working pressure	250 lb.
Fuel	Soft coal

Firebox

Material	Steel
Staying	Belpaire
Length	125⁵⁄₁₆ ins.
Width	79⅞ ins.
Depth, front	89⅛ ins.
Depth, back	59¾ ins.

Tubes

Diameter	3½ ins.	2¼ ins.
Number	170	120
Length	19 ft. 1 in.	19 ft. 1 in.

Heating Surface

Firebox	206 sq. ft.
Combustion chamber	164 sq. ft.
Tubes	4303 sq. ft.
Firebrick tubes	29 sq. ft.
Total	4702 sq. ft.
Superheater	1630 sq. ft.
Grate area	69.9 sq. ft.

DRIVING WHEELS

Diameter, outside	72 ins.
Diameter, center	64 ins.
Journals, main	12 ins. x 16 ins.
Journals, others	11 ins. x 16 ins.

ENGINE TRUCK WHEELS

Diameter, front	33 ins.
Journals	6½ ins. x 12 ins.
Diameter, back	50 ins.
Journals	6½ ins. x 12 ins.

WHEEL BASE

Driving	18 ft. 10 ins.
Rigid	18 ft. 10 ins.
Total engine	41 ft. 0½ ins.
Total engine and tender	79 ft. 3⅞ ins.

WEIGHT

In Working Order

On driving wheels	266,500 lb.
On truck, front	59,300 lb.
On truck, back	56,600 lb.
Total engine	382,400 lb.
Total engine and tender	600,300 lb.

TENDER

Wheels, number	Eight
Wheels, diameter	36 ins.
Journals	6½ ins. x 12 ins.
Tank capacity	11,000 U. S. gal.
Fuel capacity	35,000 lb.
Tractive force	64,550 lb.
Service	Fast freight

The New Electrification on the Great Northern Railway

Motor Generator Locomotives Used Are Largest of the Type Ever Built

The electrification project now under way on the Great Northern Railway has attracted great attention among railway officials and electrical engineers because of the new system adopted, and the retirement of one of the pioneer electrifications in America, a three-phase system, to give place to the new work. The present undertaking involves the revision of the original electrification between Tye, Washington, at the western end of the Cascade Tunnel and the eastern portal of the same tunnel, and the extension of the electrification westward to Skykomish, Washington. The electrified mileage will thus be increased from four miles to 24 miles of main line trackage, exclusive of yards.

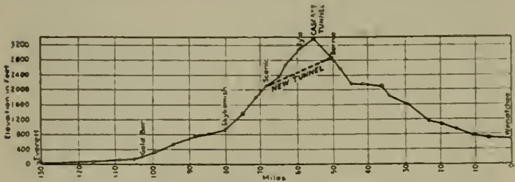
Two Unit Motor Generator Locomotives of the Great Northern Railway

This electrification project constitutes what is reported to be the first step in a program that will include 96 miles of main line via a new tunnel, from Gold Bar to Wenatchee.

By eliminating the duplication of helper service, the delays caused thereby, and other losses of time incident to steam operation such as watering, refueling, standby losses, etc., the electrification is calculated to bring material savings in operating costs. In addition, it will permit faster train movement over the section involved and will virtually fulfill in every respect the requirements of present operating conditions. Consideration has been given to future requirements by an ample allowance for expansion.

In order to secure the advantages of alternating-current transmission and trolley and the direct-current traction motors, the motor-generator type of locomotive was chosen. This will draw power from an 11,000-volt single-phase, 25-cycle trolley. By using this type of locomotive it is possible to take advantage of the inherent merits of both the alternating-current and the direct-current systems. This means high-voltage transmission to the locomotives with minimum copper loss and power loss, static unattended transformer stations along the railway line, light overhead construction, plus the advantages of direct-current traction motors and practically unlimited flexibility of control in operation and regeneration.

The main line of the Great Northern which extends from St. Paul, Minnesota, to Washington, has the lowest ruling grade to the Pacific Coast of any of our western railroads. The line is laid with heavy rails and is double-tracked at most of the critical points. The heaviest and



Profile of Great Northern Electrification

most severe grades against load movement are encountered in crossing the Cascade mountains in Washington, where the line is single track. Here the rise to the summit on both sides is very precipitous, and on the west slope a very circuitous route is required to make the ascent. Many snowsheds are required to shelter this section of the line from the deep snow and slides during the winter season.

There are several tunnels along the circuitous route on the western slope, the longest of which is the Cascade tunnel, at the summit. This tunnel, constructed on a 1.7 per cent grade, is about 2.75 miles long. The original electrification which is now undergoing modification, was installed through this tunnel in 1909, mainly for the purpose of eliminating gas and smoke so as to expedite train movement. It extended from Tye at the west portal to Cascade Tunnel Station at the eastern portal, and comprised four miles of main line track and four miles of yard trackage. The 6,600-volt, a-c. three-phase, 25-cycle system was used with a double overhead catenary trolley.

When the original installation was made there was no electric power supply within available distance from which power could be obtained. This necessitated the erection of a hydro-electric generating station at Tunwater on the Wenatchee River, a distance of thirty miles from the tunnel. Power produced here by two 2,000-kw. three-phase, 25-cycle, 6,600-volt units was transmitted to the substation at Cascade Tunnel at 33,000 volts. Water was brought to the plant, which operated under a head of 176 feet, in an 8½ foot flume, two and one-half miles long.

The original electrification itself undoubtedly has served the purpose for which it was installed—the relief from an intolerable condition under steam operation. However, because of its special requirements of organization and operation, the electric service has been tolerated under extremely high operating costs.

Between Seattle and Skykomish, the profile shows that the grades are not unduly heavy, nor are the curvatures excessive, the heavy grades and curves being confined to that section on the west slope of the Cascade mountains, between Skykomish and Cascade tunnel and on the east slope between Cascade tunnel and Leavenworth. With conditions on the east slope the railways is not especially concerned at this time, as certain contemplated changes in line with other reasons, have for the present delayed the electrification of that side. On the west slope, however, a continuous grade of 2.2 per cent is encountered from Skykomish to Tye, a distance of 21.4 miles, with curvatures up to 10 degrees, and from Tye to the summit of the range, through the Cascade tunnel, the grade is 1.7 per cent.

Steam Operation

A 2,500-ton time freight, out of Seattle, or rather Interbay, the terminal yard, consisting of about 60 cars, covers the 80 miles to Skykomish in approximately 5½ hours when hauled by a 250-ton Mikado type 2-8-2 oil burning locomotive having a normal tractive power of 64,300 lb. At Skykomish two 2-6 + 8-0 mallet type locomotives of 260 tons and developing a tractive effort of 78,300 lb. are cut into the train at about uniform distance apart, to assist on the 2.2 per cent grade to Tye. Including a delay at Skykomish for this operation of one hour and for water at Scenic of 20 minutes, the 21.4 miles to Tye is covered in 4½ hours. On arrival at Tye, the steam helpers are replaced by the electric locomotives, located two ahead and two in the center of the train, and from Tye, the run to Cascade tunnel station is made in 22 minutes. Allowing 15 minutes at Cascade tunnel for cutting out the electrics and inspecting air brakes, the train when reassembled completes the remaining 53 miles to Wenatchee in four hours.

After a thorough review of operation, the Great Northern management, realizing that considerable improvement could be made in the schedule and a substantial reduction in operating expenses, authorized electrification that would accomplish the desired results. This authorization provided for a new system of electrification as past experience dictated that extension of the original system was inadvisable.

The experience, both favorable and unfavorable, gained from the original electrification was very helpful in selecting the new 11,000-volt, 25-cycle, single-phase system.

Some of the reasons for the use of 25 cycles on the new system as compared with the standard commercial frequency of 60 cycles are:

1. Facilitates use of full capacity of 6,000-kw., 25-cycle output of Tumwater plant because of liberal design of three-phase machines which make possible full nameplate capacity at single-phase.
2. Some kind of rotating apparatus would have been required to convert single-phase railway load into balanced three-phase load on the power system supplying the energy.
3. 25 cycles is standard for railway transformers and much other equipment which has been developed.
4. Less interference with communication circuits at 25 cycles.
5. Regulation of 25-cycle system is considerably better on fluctuating loads, and losses are less than on 60-cycle system.
6. Copper ground return because of higher impedence of rails would have been required for 60 cycles.

With the limitations contemplated in the power supply for the new electrification, it will be possible always to operate at practically an unlimited number of speeds up to the continuous rating of a locomotive because of the great flexibility of the motor-generator type unit. Furthermore, the method of accelerating a train by means of voltage control of the motor is ideal from the standpoint of economy, both in starting losses and in power demand from the sources of supply and by using a synchronous motor to drive the motor generator set on the locomotive, power-factor correction is obtained, making practically the entire output of the station useful power.

For regenerating braking, the same flexibility of control is available as in motoring. It is possible to regenerate at all speeds within the established range of the locomotive, to practically standstill. The varied train weights over this section and the conformation of the country, make this wide range a very effective feature, as the speed, while regenerating, can be adjusted to suit the grade of any particular section.

The two new Baldwin-Westinghouse electric locomotives for the Great Northern each consist of two cabs which are identical, mechanically and electrically. Each one of these units is self-contained, that is, fully equipped to operate alone. Present plans are to operate two cabs as a road locomotive. Each locomotive weighs about 715,000 punds, is 94 ft. 4 in. long and has a continuous rating of 88,500 pounds tractive effort 15.5 mph. Maximum allowable speed is 37.5 mph. and maximum rating is almost 7,000 hp.

These two-unit locomotives are the most powerful of this type ever built. One of them has been delivered to the Great Northern at Skykomish and the other will be completed in December.

The Great Northern has contracted with the Puget Sound Power & Light Company to supply all power for the electrification. Under the agreement the Tumwater generating plant will be operated by the power company and tied in with its system through a 44-kv. railway transmission line at present and later possibly by its 110-kv. transmission line going via another route over the mountains to Wenatchee.

The present project involved the construction of a 110-kv. three-phase, 60-cycle transmission line from the Beverly substation of the power company, near Everett, Washington, to Skykomish; the erection of two new outdoor substations at Scenic and Cascade, respectively, a frequency change set will also be installed in the Skykomish station where connection is made with the 110-kv. transmission line of the power company and the 44-kv. railway transmission line, which is also being erected at this time from Skykomish to Tumwater.

The two 44-kv. railway transmission lines, the trolley construction and signal line will all be carried on single poles along the right-of-way. The trolley contact line is No. 4/0 cadmium bronze supported by inclined catenary type of construction.

Careful consideration has been given to possible interference to signal and communication lines due to the single-phase system. The d-c. signal system will be changed to a-c. 60-cycles with 6,600-volt transmission. Telegraph and telephone lines enroute will undergo general revamping, using necessary cables or removing them from the right-of-way entirely. Local telephone lines heretofore adjacent to the right-of-way will be removed to a convenient distance therefrom to avoid inductive troubles. Distance as the most effective remedy has been the general basis on which the problem of inductive interference has been considered.

Metering presented some interesting problems to the power company owing to the condition of the contract which calls for the simultaneous measurement of demand at two widely separated points. In addition, it is necessary to take into account power fed back into the power company's system by the Tumwater plant and by the electric locomotives when regenerating. Power will be measured by two three-phase ratchet meters at each point and demands will be measured by graphic meters to obtain simultaneous records at the two points.

According to the contract billing for power will be made on the basis of the average of the three highest five-minute demands during the month. In the event of power failure any peaks occurring during the first fifteen minutes after service is restored are to be ignored. As all power taken by the railway company from the 110-kv. line of the power company will first pass through the frequency changers, driven by synchronous motors, it will be possible to maintain unity power factor or even a leading power factor if desired.

Simultaneously with the rehabilitation and extension of the original electric section, a new tunnel through the Cascade Mountains was begun, and when completed this will be the longest railways tunnel in America—seven and three-quarter miles. The present line crosses the divide at an elevation of 3,385 feet above sea level. It has sharp grades and curves, numerous snowsheds and several tunnels, one of which is the Cascade, 13,873 feet long. On account of heavy snowfall, which reaches a maximum of 410 inches at one point and 670 inches at the Cascade Tunnel each season, it is difficult and expensive to keep the line open for operation. Increasing importance of a thoroughly dependable line, the necessity for additional snowsheds on the present route and the heavy repairs on the existing snowsheds brought expenditures to a point where a new line on a lower level would show a substantial gain.

The new tunnel line will shorten the right-of-way more than 7½ miles, eliminate nearly six complete circles of curvature and will escape most of the severe snow trouble. The grade will be the same as the present tunnel, but the elevation will be 500 feet lower. Electric power is being used throughout in its construction which it is expected will be completed in about two years.

Special Designed Flat Car to Carry Merchandise Dispatch Trailers

The economical handling of less than carload freight has been made by the Chicago, North Shore and Milwaukee Railroad with the design of a special type flat car to carry merchandise dispatch trailers without the removal of wheels. This is the first of its kind ever placed in service.

Runways are provided whereby two trailers are mounted on each flat car. Interlocking devices hold the trailers.

The saving in time and expense of handling make this new equipment an outstanding development of freight transportation. The trailers eliminate all extra handling being loaded at the point of departure and unloaded at destination.

The trailers will be hauled by motor truck when they will be mounted on flat car. Several flat car and trailers already have been delivered and the balance is scheduled for delivery at an early date. New chassis also have been ordered to convert trailers now in use. The trailers are of eight-ton capacity, with a metal container bodies 7 x 17 feet. The new equipment will be used on regular schedule in service on the North Shore and Milwaukee Railroad.

Difficulties were encountered in adapting the flat cars to carry the trailers. In order to bring the tops of the trailers down low enough to clear overhead construction. This made it necessary to cut away the ends of the cars to provide space for the movement of the radial draw bar and coupler.

Tractors draw the trailers up the runways on to the flat cars. The fifth wheel of the tractor, which bears the front end weight of the trailers, is released and locked to the tractor and at the same time the trailer is lowered on the steel side supports.

A further improvement has been made in the flat cars now on order for carrying trailers. Instead of the jaw type pedestals, the side support has been made from designs prepared by engineers of the company.

Cutting Down the Operating Costs*

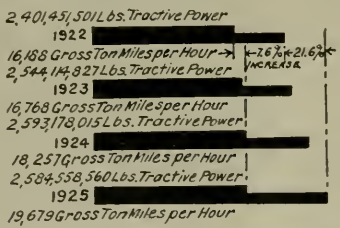
By W. E. WOODARD, Vice President, Lima Locomotive Works

Just three weeks before his death, the late George Basford wrote the following to one of his friends: "I believe that the change from the locomotive that we have known so long to the locomotive power plant of high horse-power output that we now have, and it is getting better every day, offers the largest opportunity yet for reducing the cost of hauling tonnage."

This is the job of the railway man, reducing the cost of hauling tonnage, and it is my purpose to show you how some of the more recent contributions to the art of locomotive building offer the means for cutting operating costs.

American railways have made notable records in the past few years in improving operation. The results are most interesting, not alone to show how fast the art of railroading is advancing but, more important for our present purpose, the means through which this is being accomplished and the probable trend or line of future improvements.

Gross ton miles per train hours gives a more reliable index than any other single figure as to the rate at which railways are moving tonnage. It may be regarded as an index of the extent to which railways are utilizing their transportation plants. Chart 1 shows that the railways of the country from 1922 to 1925 increased this figure 21.6 per cent and what is even more significant, they did this with only a 7.6 per cent increase in total locomotive tractive power. This, truly was a remarkable achievement and the members of this association played no small part in the accomplishment. To the locomotive designer and builder this splendid record is significant because it shows that power output is becoming more and more a requirement in fitting locomotive designs into railway companies needs. While improvements such as better signalling, improved siding and yard facilities, as well as an increase in average car capacity, unquestionably provided some of the means whereby this increase was secured, the fact remains that it could only have been accomplished by a marked increase in the average drawbar horsepower output of the locomotives.



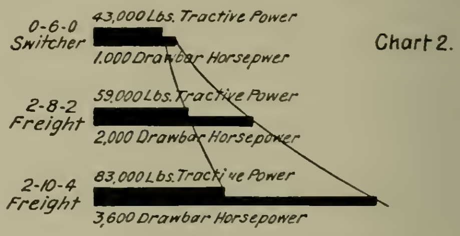
Tractive Power and Tonnage Movement

An example from a recent road test well illustrated how tonnage and speed affect this figure. A 2-8-2 locomotive handled 1,691 tons in 46 cars over about 46 miles, much of it one per cent up-grade, at an average speed of 14¼ miles per hour. In doing this the engine developed an average drawbar horsepower of 1,150. On the same day over the same division, a 2-8-4 type locomotive handled 2,296 tons in 54 cars, at an average speed of 19.9 miles an hour. The average drawbar horsepower shown on the dynamometer car was 1,784. The data are absolutely comparative, because the runs were made on the same day under the same weather conditions. The heavier train at the higher speed required 55 per cent more drawbar horsepower output. These figures are mentioned simply to illustrate what the demand for increased tonnage at higher speed means in terms of power output of the locomotive. These greater requirements often mean the use of a motive power unit of a different class in order to meet the traffic condition without a sacrifice in tonnage.

In the study of this situation, there is one element which is of special interest; namely, the allowable driving-wheel loads. For the past few years the maximum allowable driver-wheel weight has not been increased, and there is no indication that it will be materially increased in the near future. Therefore, any improvement in the locomotive must come through a more intensive production of power per unit of weight.

In considering the present day locomotive as a moving power plant; which it really is, we can omit from the discussion reference to variations in detail design and focus attention on the fundamental problem. How can we obtain the increased drawbar horsepower which future traffic conditions will demand within existing driver-wheel weights, always keeping in mind locomotive fuel efficiency?

In order that we may get clearly in mind the meaning of the term "drawbar horsepower," I should like to point out the difference between horsepower and tractive power. Tractive power is the pull exerted by the cylinders at the rim of the driving wheels. If we subtract from tractive power the pull required to move the engine and tender, we get drawbar pull. Drawbar horsepower is the rate at which drawbar pull is produced. As shown on chart 2, a heavy six-wheel switcher having a tractive power of 43,000 pounds can produce a 33,000 pound drawbar pull at 1,000 feet a minute, or 11.2 miles an hour. This equals exactly 1,000 drawbar horsepower. (One horsepower is 33,000 pounds pull over a distance of one foot in one minute; hence, 33,000 drawbar pull at 1,000 feet a minute equals 1,000 drawbar horsepower.) An average freight engine having a tractive power of 59,000 pounds will produce 33,000 pounds drawbar pull at 2,000 feet a minute, 22.6 miles an hour. This is 2,000 drawbar horsepower. One of our biggest freight units having a tractive power of 83,000 pounds can produce 33,000 pounds drawbar pull at 3,600 feet a minute, or 41 miles an hour. This is 3,600 drawbar horsepower. Note that the big freight engine will produce 3.6 times as much drawbar horsepower as the switcher, whereas the maximum tractive power of the big engine is less than two times as much the switcher. The big freight unit will produce almost twice the drawbar horsepower of the aver-



The Increase in Drawbar Horsepower

*A Paper presented to the Traveling Engineers Association.

age freight engine, whereas its maximum tractive power is only 1.4 times as much.

While this comparison is made between locomotives of different classes, in order to bring out clearly the relation between tractive power and drawbar horsepower, the same thing is true to a lesser degree between locomotives of the same class. Maximum tractive power is no longer an index of the capacity of a locomotive to pull tonnage over a railroad. This statement is confirmed by the operating results already mentioned. From 1922 to 1925 the per cent of increase in gross ton miles per train hour (21.6 per cent) was almost three times the per cent of increase in the total tractive power of the locomotives (7.6 per cent). Beyond question one large element in this result was the more extensive use of modern motive power units in which the proportion of horsepower output to tractive power is far greater than in the older types of engines. If we wish, therefore, to find the value of a locomotive design for producing gross ton miles per hour, major consideration must be given to its drawbar horsepower.

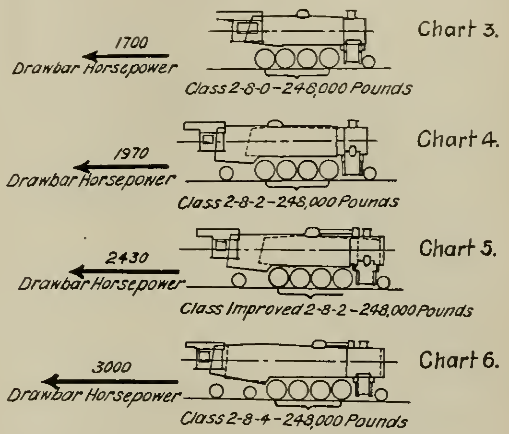
I do not want to give the impression that we have discovered anything new when we talk about increasing the drawbar horsepower output of a locomotive. However, we now realize more clearly the importance of this factor in relation to railway operation, and it is only in recent designs that we have made a deliberate effort to improve this factor by changing some of the relations which existed in locomotive designs of the past.

Until a short time ago any increase in locomotive power capacity was secured by the use of well-known and existing combinations. How these steps progressed over a number of years past the following charts will show. Chart 3 shows a Consolidation locomotive of about 62,000 pounds per pair of driving wheels and its power output at 25 miles an hour. This general type of locomotive for a number of years was the standard freight unit of the country. As the traffic demands became greater, the same driving-wheel arrangement was used and the additional power secured by the application of a large boiler and trailing truck wheels, with the result that the well-known Mikado type was developed. This type of locomotive and its power output is shown on Chart 4, on the same driving wheel arrangement and load as the Consolidation. The response to the urge for more and more power was a design of the same general type, but with added steam generating capacity in the boiler, resulting from the use of type E superheater, feedwater heater, and other refinements of design. This power unit is shown on Chart 5, which is again superimposed upon the same driving wheel arrangement and driving wheel weight as the Consolidation. The last step consisted almost entirely of added boiler capacity, and it practically exhausted the possibilities of using the well-known and existing element of locomotive design for securing maximum power output on a given arrangement of driving wheels and a given driver-wheel weight. The next step, and one which represents a number of locomotives now in use and being built, was to get more cylinder power into the same driver-wheel weight and furnish means in the boiler for supplying steam for this added cylinder power. This problem has been approached from two different angles by different builders. One method, which is now represented in 105 locomotives in use or building, is to increase the cylinder power by limiting cut-off and raising the boiler pressure. Thus has the effect of keeping the maximum tractive power at about the same point or slightly higher than the older designs, but raises the drawbar horsepower at operating speeds in proportion to the increase in pressure. Such a design is shown on chart 6, again superimposed upon the same driver-wheel arrangement and weight as the old Consolidation type engine.

Added cylinder power output also can be secured by the use of three-cylinders with a boiler of sufficient size to supply the cylinder requirements. The result is a similar increase in drawbar horsepower output.

In these comparisons the part played by the boiler in increasing the power output is very apparent, and it is only through higher boiler capacity that cylinder power output can be increased. To the locomotive designer the problem of securing greater capacity in the cylinders is relatively easy; the real problem is to get boiler capacity to supply the increased cylinder requirements.

In this comparison of the four locomotives all upon the same driver-wheel arrangement and driver-weight, I have used actual locomotives and eliminated the variable of driving-wheel load and arrangement, thus making the diagrams comparable. Most of the data is from actual dynamometer car tests, and such few figures as have been



A Comparison Showing Locomotive Development

calculated are based upon actual data, so that the power output is what has been and what is actually being obtained in service at 25 miles an hour.

From the Consolidation, the standard locomotive of a few years ago, to the modern 2-8-4 power output has been increased 76½ per cent without altering driver-wheel arrangement and weight. Here is one of the reasons why the railways could make the showing they did in gross ton miles per train hour output from 1922 to 1925. How much improvement is still possible can be gathered from the number of older and smaller locomotives still in use. Of the locomotives assigned to freight service in 1925 about 40 per cent were Consolidations, almost all of them less powerful than the Consolidation I have shown in the diagram; 22½ per cent of all the freight power in 1925 were of the Mikado type many of them not as powerful as the Mikado I have shown. With all due allowance for the needs of branch line and pick up service, these figures reveal the possibility of savings in operation by the substitution of new and improved motive power units.

The comparison has been made upon freight power, as the advance could be morely easily traced in the classes of locomotive used in this service. The same principle of increased power output are applicable to passenger locomotives, but in the line we do not seem to be as far advanced as we are in the locomotive for freight service.

I have confined myself to this rather elementary talk on locomotive power output because of the following

reasons, which are a summary of what I have already said.

A study of traffic figures clearly revels a strong trend toward more tonnage at higher speeds; this means more gross ton mile output per train hours which results in increased demands for power output from the locomotive units.

The allowable driving-wheel loads have remained and probably will remain about stationary. Logically, therefore, the line of progress is to get the greatest amount of power obtainable out of the existing driver-wheel loads.

The diagrams show what already has been done. The locomotive of today is being made to fit the operating conditions now being developed on the railways and such a locomotive can briefly be described about as follows:

For a freight unit of 60,000 pound axle load, a locomotive which will develop from 3,000 to 3,600 drawbar horsepower with a boiler of sufficient size to generate steam for this output at combustion rate of not over 100 pounds of coal per square foot of grate per hour. For lighter axle loads, a drawbar horsepower output in proportion to allowable wheel loads, the maximum combustion rate remaining at 100 pounds of coal per square foot grate.

This sounds simple. There are a few locomotives running which meet these requirements. This specification stands for the best freight units of the present day.

Freight Car Inspection*

By A. J. KRUEGER, Master Car Builder, New York, Chicago & St. Louis Railroad

Freight car inspection in its relation to freight train operation is one of the most important and difficult problems confronting the railroads today. The successful operation of freight trains fundamentally depends upon the ability of the railroad to obtain a proper freight car inspection and in this manner move trains with full capacity tonnage from one terminal to another without interruption on account of equipment failures. In order to accomplish this, it requires positive freight car inspection, as well as maintaining such inspection at all times.

Ordinarily there are two ways in which inspection can be performed. One is termed Positive, the other Negative. Positive inspection can be secured by means of a well-organized force of inspectors, properly instructed and supervised and regularly assigned to perform certain duties and in this manner specialize in their work and know, beyond the question of a doubt, that every part of the car body and trucks has been properly inspected. Negative inspection is secured by making inspection in a general way without any well defined system set up covering the duties to be performed by each inspector and which condition can easily be found in a great many railroad yards today. When we analyze this situation, we cannot be surprised at the failures which occur; considering the short period of time in which the inspector is required to perform his work. Positive inspection cannot be accomplished unless we give consideration to some of the things which are essential to make it successful.

In making inspection of a freight car under common present-day methods, the inspector is usually required to observe the condition of all parts on car body and truck, except possibly the air brake and journal boxes, in a very short period of time. Inspection made in this manner make it necessary for each inspector to detect, among other things, the following:

Loose and missing box and column bolt nuts.

Condition of journal boxes, truck springs, spring planks, truck bolsters, arch bar, or side frames.

Condition of brake rigging, which is intended to mean that the inspector should observe the condition of brake beams and hangers, brake beam truss rods and nuts, fulcrums, compression and tension members, brake head, brake shoes and keys, bottom connections, brake levers, and most important of all to know that all brake and brake hanger pins have cotters properly spread and in good condition, or a suitable device for holding the pins in place.

Condition of wheels by inspecting the cracked plates, broken rims, loose wheels and other condemnable wheel defects.

* Abstract of a paper read before the Cleveland Steam Railway Club.

Condition of safety appliances, couplers and parts, draft gear and parts.

Condition of car body, including underframe, ends, sides and doors, roof and running boards.

These are some of the things we expect our freight car inspectors to do and when we devote the proper attention to the possibility of accomplishing this, it seems that this kind of inspection can better be accomplished by specializing or classifying the work; in other words, to assign definitely to certain men the inspection of certain parts of the car body and trucks.

Progressive Repair Methods

The progressive car repair shops of today are operating on this basis and some progress in freight car inspection has been made along these lines, as invariably the airbrake inspection and inspection of journal boxes and contained parts is made in this manner at most railroad terminals at the present time. There appears to be no reason, therefore, why this policy could not be successfully extended, and, as an example, could be operated somewhat in the following manner:

1. Car oilers assigned to lifting journal box lids, making careful examination of journal bearings, journal bearing wedges, journal box packing, making repairs where required and making sure there is no evidence of heating or trouble on account of hot boxes.
2. Inspectors assigned to air-brake inspection and repairs.
3. Inspectors assigned to trucks, including all truck parts, brake rigging and wheel inspection and repairs.
4. Inspectors assigned to couplers and parts draft gears and safety appliance inspection and repairs.
5. Inspectors assigned to general condition of car body, side doors and roof inspection and repairs.

This plan can, of course, be modified to suit local conditions as they exist and when we consider that the more efficient our freight car inspection and repairs become in our train yards, it should reflect a decrease in the number of cars condemned to the repair tracks.

Specializing or classifying car inspection requires an analysis on the part of our supervisor to select men particularly suited to the individual requirements of the assigned position. It has been found that men were selected for inspectors from repair track forces at random and sent out to inspect trains without the supervision spending enough time to instruct them properly for this work, which results in men being out in the train yard as inspectors who really "don't know where they are going, but are on their way."

Essential to positive freight car inspection is the manner in which interchange inspection is performed. Ordinarily we think of interchange inspection made at some outlying inspection point where the inspector usually has sufficient time to go over the car three or four times if necessary and at such location there should not be much occasion for failure to secure proper inspection and repairs. However, interchange inspection as performed at large originating terminal presents no easy problem to solve. We all, no doubt, have puller trains coming from connections or industries which are delivered at four or five different locations, making it necessary either to establish separate inspection forces, or require inspectors to go from one location to another, which consumes considerable time. This, therefore, among other things suggests that considerable improvement in inspection and conservation of time should be secured if arrangements are made to concentrate car inspection at designated locations with a force sufficient to specialize on the inspection and make repairs at the same time.

Co-Operation Vitally Important

In order to do this, close co-operation is required between the transportation and mechanical departments, so that the proper track can be selected and assigned for this purpose to make it possible for the mechanical department to function properly in this respect consistent with the facilities available.

Adequate material supply for inspectors and train yard repairmen, as well as an effective means of transporting such material, is in most cases such that it actually makes it a burden for the inspector to make the necessary repairs in the train yard. It is no uncommon sight to see an inspector crawl in between cars and walk a considerable distance to secure a knuckle or lock or other items to make a repair and the greater the hardship we work upon the inspector to do this, the greater the liability for the inspector to take a chance and permit the defective part to continue in service.

Important to freight car inspection is the manner in which equipment failures are investigated. Usually such investigations are made by the local supervisor in charge in the territory where such failures occur. Very often, in making such investigations, we find occasion to criticize the inspector for failure to observe the defective condition of the part which caused trouble, without deciding if the inspector has been properly instructed, if he is competent to perform the work required of him and if he has sufficient time to make positive inspection. I am inclined to think that we are too ready to jump all over the inspector for his shortcomings, in place of deciding what can be done to help him.

Considerable improvement could be brought about by creating a desire on the part of the inspector to feel free to make recommendations, or suggestions, to his foreman in connection with his work. This can be accomplished by making the inspector feel that he is an important and necessary part of the organization created by means of close frequent contact on the part of the local supervisor and will result as well in the supervisor becoming intimate with the peculiar problems and difficulties that the inspector is up against. It is certainly worth while to hold meetings with our inspectors at regular stated intervals so that he will become accustomed to looking forward to such a meeting for the free discussion of problems, current instructions issued and the effective A. R. A. rules of interchange which apply to his work.

We often find that certain instructions which have been issued are not being followed and upon looking into this we discover that there has been no method established for providing the inspectors with such instructions.

The kind of tools and gages which are supplied to inspectors for their work is of the utmost importance and also that he knows how to use them. Take for example the use of the A. R. A. wheel and coupler gage: How often do any of us make it a point to find out if the inspector really knows how to use it and if we know all about it ourselves?

Some Improvements in Operating Results

On the other hand the character of the repairs made to cars on repair tracks can be of material assistance to the inspector in his work by turning out repaired equipment which will operate in service without causing failure.

This review on freight car inspection is principally confined to the more important items which it is felt will produce positive inspection and in which specialized inspection is advocated. The results which can be obtained by proper freight car inspection with respect to train operation can, among other things, be measured by means of the following:

1. Decrease in average time of trains between terminals.
2. Decrease in numbers of cars set out, or causing delay to trains account of defective equipment, which permit increase in tonnage.
3. Decrease in number of pounds of coal consumed per thousand gross ton miles.
4. Increase in percentage of fast freight trains making assigned schedules.
5. Increase in freight car miles per hot box.

Railroad revenue is derived exclusively through its transportation service to the public, which cannot be obtained without making it possible to operate freight trains quickly and safely and which, among other things, depends largely upon the various types of inspection of freight cars as follows:

1. The inspection made to the empty car to determine its fitness to carry the load intended.
2. The interchange inspection and repairs made at the originating point on each line.
3. The terminal inspection and repairs made while the car is en route.

There are so many things indirectly concerned with the accomplishment of proper freight car inspection, that it requires continual study and analysis.

The manner in which we are today performing freight car inspection at large terminals has made very little progress as compared with the way in which it was done since railroads were first operated.

In visualizing the improvements which can be made to secure the highest standard of freight car inspection, it is not hard to realize that the future will develop a method for inspection upon the arrival of freight trains pulling into terminals and stopping at locations which are in reality our light repair tracks of today where we will find adequate facilities and materials of all kinds conveniently located with a sufficient force of competent men to make inspection and repairs quickly and thoroughly under a well organized plan which will result in less handling of bad order cars and insure the possibility of accomplishing that which appears impossible.

Freight car inspection is so vital to the success of the railroad that it is necessary for our supervisors continually to stimulate interest and enthusiasm and impress this permanently in the minds of themselves, as well as on the men doing the work. If we keep both eyes open to the opportunities for improvement this cannot help but reflect a decrease in equipment failures and will assist the great common carrier of today in taking one more step in the direction of progress and fulfilling a responsibility in serving the public efficiently and safely.

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Roller Bearings Reduce Train Resistance

One of the major items of railway operating expense pertains to the various phases of "Train Resistance," which includes as one of its factors the element of friction. Consequently, any means or agency through which the retarding effect of friction in moving trains is reduced tends to more economical operation. A glance at the sum total expended by our railways for fuel and lubrication alone, discloses a wonderfully inviting field for effecting great economies in this and other related phases of our transportation system.

Elsewhere in this issue will be found a most interesting report by L. K. Sillcox, general superintendent of motive power of the Chicago, Milwaukee & St. Paul Railway on the results of tests made with roller bearing equipped cars and the decision to apply this type of bearing in place of the standard A. R. A. brass bearing to a total of 127 modern passenger cars, 64 of which are new Pullmans and 63 standard St. Paul stock. The number of roller bearings applied will therefore total 1,524.

Mr. Sillcox has not gone into the matter on what may appear to be so large a scale without first having conducted quite an extended series of tests or trials of the various kinds of roller bearings. The results of his investigations were so convincing to him as to fully justify the departure from standard practice.

Rolling friction is without question one of the main factors to be considered in starting trains and any device or method that will materially reduce it should be given every consideration.

In the tests conducted by Mr. Sillcox to establish the relative difference in rolling friction in starting cars equipped with roller bearings as compared with the ordinary A. R. A. brass bearings, he found that the resistance in pounds per ton for a sleeper equipped with the latter was 55.8, while with a standard steel coach equipped with roller bearings the resistance was only 7.59 lbs. per ton. In other words, the resistance was seven times greater with the plain A. R. A. lubricated journal.

We are rather surprised at the unusually high resistances developed in these tests in the starting of the coach and the standard sleeping car equipped with the usual brass bearings. Mr. Sillcox found that in one instance it was 54.4 and in the other 55.8 lbs. per ton. In common practice this has usually been considered to range only from 12 to 15 lbs. and occasionally somewhat above the latter figure. While there are many factors effecting train movement that are not dealt with in the investigation under consideration, it will be highly interesting indeed to learn of the practical results obtained from this substitution of roller bearings for the standard bearing now in use.

With such wonderful results in favor of the roller bearing after extended investigation in practical tests, it is not strange that Mr. Sillcox saw in this type of journal bearing a practical means of materially reducing the element of journal or rolling friction which now retards in no small degree the starting of trains.

Water Analysis

It may be that a dog can get too old to learn new tricks, but in the matter of incrustation or scale and the formulæ for the determination of the quantity and hardness of scale some of us experience difficulty in comprehending them. Water analysis is now dealt with in terms of ions and the analyses given are quite unintelligible to the majority of laymen who have not yet thoroughly absorbed the new ideas.

We are not enough of chemists to decide if it is possible or no, but if it is, it would be well to give not only the old-fashioned ordinary analysis of a sample of water and add to it the rule or rules for the conversion of the analysis into the ion readings, that the common man can learn the connection between the two. When it comes to corrosion and corrosive waters let the same be done. It may be a troublesome or difficult thing to accomplish, but the added value given to such analyses, if it can be done, will be more than worth any work that may be involved in the doing of it.

Since the ionic theory of chemical interaction is comparatively new, and most of us are still thinking and asking for analyses in the old terms of grains of the different constituents per gallon, it seems proper that analyses be so constructed as to give parallel data between the two methods so that the layman may read and make intelligent comparisons. As these things are very often handled now it seems to be very much as though a paper dealing solely with metric units and without any reference to their relation to English measurements, were to be addressed to an audience of workmen who had never heard of the metric system. Its value would be quite nullified by its unintelligbleness.

British Railroad Accidents Increase

The annual report of the Ministry of Transport, a British government body analogous to the Interstate Commerce Commission of the United States, on accidents on the railroads of Great Britain in 1925, which has just been published, shows that railroad accidents in the United Kingdom are increasing. The official report shows that

465 persons were killed in 1925, an increase of 3 over 1924, and 26,393 were injured, an increase of 752 over the preceding year and an increase of 2,757 over the average total number injured in the period from 1914 to 1923. To make these figures comparable with accident reports of the Interstate Commerce Commission there should be added 356 suicides and trespassers killed and 51 injured, not included in the foregoing, making the grand totals 821 killed and 26,384 injured.

Seventy-six passengers were killed on British railroads in 1925 instead of "only one," as stated in London dispatches widely circulated by American newspapers on four different dates since January 1, and 4,377 passengers were injured, an increase of 411 over 1924 and an increase of 1,578 over the annual average from 1914 to 1923.

Some of these accidents to passengers would be altogether impossible on American railroads. For instance, no fewer than 19 passengers were killed by falling out of cars while trains were running. These accidents were attributable to the compartment cars in use on British railroads. Commenting on other accidents due to the same cause, the Ministry of Transport has this to say:

"Liability to injury in the case of a train accident is largely dependent upon the character of the passenger stock concerned. A case of a buffer-stop collision during 1925 in which 72 passengers were injured is illustrative of this fact. The train in this case was composed of six-wheeled vehicles averaging over forty years old and weighing only thirteen and a half tons each."

Sixty-six collisions and derailments were caused by failure of the antiquated couplings with which most British cars are equipped. In this particular class of accidents 3 employees were killed and 7 passengers and 10 employees were injured. Other accidents resulting from the use of old-time couplings caused the death of 8 employees and the injury of 418 others.

In view of the widespread impression in America that there are no grade crossings and consequently no crossing accidents in Great Britain it is interesting to find 135 grade crossing accidents officially reported, in which 36 persons were killed and 13 injured.

Boiler Feed Water

Feed water for locomotive boilers has been so much to the fore during the past few years and so much has been written and published about the desirability and economy of purification and purity that we are apt to jump to the conclusion of one author, that perfect purity means a perfect water. With this anyone who has had a practical experience with boiler waters will disagree. Distilled water ought to be the ideal water for a boiler from a theoretical standpoint, but from a practical one, it most decidedly is not. It is well known that it has been found in the practical operation of boilers fed from surface condensers that the water needs the addition of some impurity, in order to overcome its corrosive tendencies, and the same holds for the use of rain water.

This is an example of making too rigid application of laboratory results to field work, and nothing is more notably true in this respect than the conclusion that, because scale shows certain insulating qualities which prevent the transmission of heat to the water in laboratory tests will cause a corresponding increase in fuel consumption in a boiler that is being crowded to a high evaporative output in service, such as obtains on locomotives. As a matter of fact, such is not the case. Of course, scale is a bad thing and the boiler which is free from it is better off than the one containing it, but the presence of a thin scale or one of moderate thickness does not produce anywhere near the increase in fuel consumption that theoretical considerations would indicate.

Aeronautical Transportation

European nations since the war have far exceeded the United States in develcping air transport. Passenger transportation has been found to be both safe and cheap, consequently, Germany, Holland and England have made such strides that something like 200 routes are on schedule and thousands travel in the air.

Germany, at present, seems to have taken leadership in the development, and now looms strongly as master of the air, spending large sums of money which in pre-war times went to the maintenance of a merchant marine and the naval budget. There are now about 1,000 commercial air planes in service in Europe. The total air routes in the world at present amount to 75,000 miles, which includes the transcontinentl route from the Atlantic to Pacific. Of this mileage, 60,000 is in Europe, of which 45,000 miles is in Germany.

Although the airplane was invented in the United States and President Coolidge is definitely committed to development of aviation, we are far behind other countries, and must bend our energies to regain the place we should occupy in this field. As an indication of the volume of business and reliability of service it may be of interest to know that durng the first six months of 1926 about 2,300,000 miles were flown by German planes transporting about 62,000 passengers and 550 tons of freight baggage and mails, with no serious accident recorded, the average regularity of schedule flights being 96 per cent which is better than some of our railways that have been in operation 75 to 80 years.

England stands second in rank in aerial transportation while the Dutch hold third place. The British and German lines connect and are in some instances affiliated financially, although on the British lines only British built machines, seating from twelve to sixteen passengers are used. Each machine has two or three engines and no single engine ships are used.

The qualifications for navigators in the British service are very high and exacting; all pilots have A-1 records and long flyng experience, licenses only being granted on passing rigid examinations in medical, technical and flying tests, and this is repeated every six months.

In addition to the foregoing each British machine carries a highly skilled airplane mechanic. The operaton of every machine is under the supervision of the British Air Ministry. A special life insurance policy is issued to those who travel on the British lines although they do not assume responsibility for personal injury, damage to person, baggage, inconvenience, etc., one of the conditions especially stipulated being as follows: "The passenger by the acceptance of this ticket takes upon himself all the risks and dangers of conveyance arising."

There are a large number of commercial airplanes operated in France and although they have carried many thousands of passengers and regularly operate between certain designated points, the leading tourist agencies are not as a rule urging patrons to forsake their old established railway lines of travel. Doubtless, as the art developes and air travel on French lines become more settled and reliable, they will become more popular with the traveling public.

It is rumored that a commercial company will shortly make its bow to the American traveler operating with all metal junker planes, capable of carrying sixteen to twenty persons equipped with 3 to 5 engines with a cruising speed of 125 miles per hour.

This line will make the New York to Chicago trip in about eight hours with one or two stops. Planes such as are contemplated for use on these routes have been built and successfully operated in Germany, and embrace many safety devices such as the "Air Gyroscope," etc.

Until quite recently, a special train has been considered the leader in swift transportation, but the rails must now wield to the air. Recently, a passenger from New York City to Moscow, Russia, stepped ashore from one of our floating palaces at Cherbourgh, France, with 85 hours of railway travel between himself and the Russian Capital. He engaged a civilian plane and alighted in Moscow 19 hours after taking to the air, a saving of 66 hours.

It is reasonable to predict that in the not far distant future, New York men will personally transact business in the principal cities between here and the Pacific Coast between Monday and Friday of the same week, returning home for the week-end. In other words a 30 day journey by rail will be condensed into a five-day trip by air.

Energy in Moving Bodies

Editor Railway and Locomotive Engineering:

Sir—A few months ago a fast express train consisting of two large locomotives backed by nine heavy Pullmans, while running at full schedule speed crashed into the rear of a similar train that was standing still on the same track on account of some trouble of its own.

The steel cars in the train ahead were telescoped to such an extent that the wreck looked like the havoc wrought by T. N. T. or as if they had been ripped open by a giant can opener. A leading technical journal, commenting on the catastrophe at the time, suggested to its readers that it would be highly interesting to compare the potential energy stored up in the moving train with the energy in a projectile fired from a 16-inch gun—the weight of the train to be taken at 1,200 tons, its velocity at 50 miles per hour.

The weight of the shell, 2,100 pounds, and its velocity 2,800 feet per second. Nothing further in regard to the suggestion appeared in print. I thought that a little time devoted to the exploitation of the matter would prove instructive as well as entertaining. The first step in the solution of such a problem is to reduce tons, miles and hours, to pounds, feet and seconds, in order that all qualities will be expressed in units of the same kind. 1,200 tons equals 2,400,000 lbs. Fifty miles per hour is identical with $\frac{50\times5{,}280}{3{,}600} = 73.33$ feet per second. The energy in a moving body is equal to its weight in pounds multiplied by the square of its velocity in feet per second divided by 64.4.

We have for the energy in the train

$$\frac{2{,}400{,}000\times73.33^2}{64.4} = 200{,}400{,}000 \text{ foot pounds}$$

$$= 100{,}200 \text{ foot tons}$$

and for the shell

$$\frac{2{,}100\times2{,}800^2}{64.4} = 255{,}600{,}000 \text{ foot pounds}$$

$$= 127{,}800 \text{ foot tons}$$

It is apparent that the energy in the shell is approximately 28 per cent greater than the energy in the train. To make matters more lucid and to correctly picture to the mind the enormous store of energy that is under the control of a man's hand, the following characteristics of a *lower* power 16-inch gun is given, the date being taken from Coast Defense U. S. A.:

Bore, 16 inches.
Travel of shell, 4.52 inches.
Muzzle energy, 77,000 foot tons.
Weight of shell, 2,400 lbs.
Velocity, 2,150 ft. sec.
Weight of nitro-cellulose (i. e., gun cotton), 612 lbs.
Penetration of wrt. iron, 46.4 inches.

Quite a respectable gun for something 15 or 20 years behind the calendar.

Penetration for any given projectile varies as the square of the velocity in feet per second. The pressure developed in such guns often is a maximum of 40,000 to 50,000 lbs. per square inch tapering down as the pressure does on an indicator card to about 2,500 lbs. per square inch at exhaust—the "mean effective pressure" being about 20,000 or 25,000 lbs. per square inch acting on a piston head of about 200 square inch area—"some card."

The most powerful gun mounted in the Canal Zone at Panama has the following characteristics:

Bore, 16 inch.
Weight, 284,000 lbs.
Projectile, 2,400 lbs.
Projectile charge, 140 lbs. gun cotton.
Gun charge, 670 lbs. gun cotton.
Energy, 84,000 foot tons.
Maximum pressure, 38,000 lbs. sq. in.
Range at 45°, 24 miles.
Muzzle velocity, 2,250 ft. sec. = 1,500 miles P.H.
Penetration, stating it will puncture any armor plate made at a distance of 11 miles.

It will be seen that this gun and the gun considered previous to it—does not measure up with the railroad train in the matter of delivering a hard blow.

High velocity whether the train or the shell is a big factor.

Engine 999 flying with two or three cars at 112 miles per hour would give a card showing 1,900 or 2,000 h.p. While a Mogul pulling a mile of cars weighing 15 or 18 hundred tons might not make a score worth looking at.

It is very seldom that power of a large gun is stated in horse-power.

Horse-power involves the element of time, 550 foot pounds per second—33,000 foot pounds per minute and 1,980,000 foot pounds per hour, are each identical with one horse-power. The energy developed by the large gun is developed in an amazingly short interval of time—hence the horse power is enormously large.

In *Ordnance and Gunnery* by O. M. Lissak, gun pressures and shell velocity within the gun are shown at 16 different points like ordinates on an indicator card.

Knowing the mean average velocity of the projectile and its travel, i.e., the distance from breech to muzzle, i.e., same length as piston stroke in an engine cylinder—the time occupied in making a stroke is easily deduced.

Applying this reasoning to our gun with 255,600,000 foot pounds of energy and velocity of 2,800 feet per second average velocity about 65 per cent of maximum in round numbers 1,820 feet per second.

Length of travel 452 inches = 37.66 ft. and time in

$$\text{seconds} = \frac{37.66}{1{,}820} = .02049 \text{ sec.}$$

$$\text{H. P.} = \frac{255{,}600{,}000}{.550\times.02049} = 22{,}460{,}000 \text{ Horse Power.}$$

The combined horse-power of all the steam—gas—oil and hydro prime movers in the U. S. A. identified with the production of electrical energy in 1924 only totaled 28,000,000 horse-power.

A little detail about that 1918—75 mile gun will be interesting in showing:

Length, 128 ft.
Weight 154 tons.
Shell weight—8.2 inch—220 lbs.
Elevation, 50 degrees.
Muzzle velocity, 4,700 ft. sec., 3,200 miles per hour.
Altitude reached by shell, 25 miles.
Foot tons,

$$\frac{220\times4{,}700^2}{2{,}000\times64.4} = 59{,}800 \text{ foot tons}$$

T. H. Reardon.

Referring to the above communication from one of our

readers in which several interesting points are touched upon with respect to the stored "energy in moving bodies." Aside from the deductions reached by our correspondent, there are other well recognized engineering principles involved and a considerable degree of flexibility or tolerance that must be allowed in calculating the horse power of locomotives. Possibly, as fair a formulæ for general use is: $\frac{T. P. \times S}{375}$ = H.P. in which T. P. is traction power and S the speed in miles per hour. The product resulting from dividing by the constant 375 approximating the horse-power at the different speeds.

The horse-power of locomotives increase with speed. In fact, the horse-power is the product of steam pressure on the pistons plus speed. The tractive power decreases with increased speed.

To better illustrate, let us assume the two engines hauling the train mentioned by our correspondent were of the modern heavy pacific type for passenger service with a tractive power of 50,000 lbs.

By using the above formulae each one of the engines would when starting a train at 4 miles per hour develop the following: $\frac{50{,}000 \times 4}{375} = 533$ horse-power, and the two combined = 1,066 horse-power. At a speed of 60 miles per hour the horse-power developed would be

$\frac{50{,}000 \times 60}{375} = 8{,}000$, and the two combined = 16,000 horse-power complete.

The energy stored up in the complete moving train, which at 60 miles per hour is 88 feet per second, is secured by our correspondent's formulae. In noting the above increase in horse-power from 1,066 at 4 miles per hour to 16,000 at 60 miles per hour it must be borne in mind that the total or maximum tractive power of 100,000 lbs. dropped correspondingly.

Another illustration of the above was the high speed passenger engine shown on page 21 of RAILWAY & LOCOMOTIVE ENGINEERING for January, 1925. This engine was credited with a spurt of speed of 120 miles per hour. When a tractive power of 25,000 lbs., this engine developed at a speed of 4 miles per hour $\frac{25{,}000 \times 4}{375} = 266$ horse-power. At a speed of 120 miles per hour the results were as follows: $\frac{25{,}000 \times 120}{375} \times 8{,}000$ horse-power.

From the foregoing it is quite clear that stored up energy in high speed railway trains and projectiles fired from heavy cannon are susceptible of comparison, bearing in mind, of course, that the projectile leaves the mouth of a cannon with a muzzle velocity of 3,500 to 4,000 feet per second and lands with a velocity of 700 to 800 feet per second, while a high speed locomotive starts with a speed of 5 to 6 feet per second and in some cases may attain a speed of 80 to 160 ft. per second.

The German long range gun which was set up in Gobain Forest, 63 miles from Paris and by means of which the Germans shelled the city was so placed that it was at an angle of 43½ degrees, the angle of elevation which gives the greatest range. The path of a fired shell from the gun attained a height of 24 miles from the earth so that it actually travelled more than 70 miles.

If there was no air resistance to overcome, a projectile with a muzzle velocity of 4,000 ft. per sec. could be fired to a height of 50 miles from the earth's surface.—EDS.

Motor Vehicles and Railroads*

The Public right to the maximum service and utility from agencies of Transportation.

By GEORGE D. OGDEN, Traffic Manager, Eastern Region, Pennsylvania Railroad

Under modern conditions of industry and society, transportation is as vital to the life of the country as the circulation of the blood is to the life of the human body. In all questions relating to transportation, therefore, the public interest is of paramount consideration. Whatever reluctance may have been manifested in the past in admitting the correctness of that viewpoint, the railroad managers and owners today accept it, the only qualification being that the private property rights of the railroads deserve the same fair treatment, consideration and protection, at the hands of the law and governing bodies, as are accorded to other forms of property.

If public interest in transportation comes first, then it necessarily follows that the public has the right to expect and demand from every form of transportation the maximum service and utility of which it is capable. This necessarily means that every form—railways, highways, waterways and airways—shall be developed and extended in the field for which it is best fitted. Conversely, it is uneconomic, and against the public interest, to develop any form of transportation in a field for which some other agency of transport is distinctly better adapted.

Any discussion of the proper relationships between motor vehicles and railroads, if it is to reach sound conclusions, must be upon the basis of these general principles.

United States a Railroad-Made Nation

The United States, as it exists today, was literally made by the railroads. One hundred years ago, at the beginning of the railroad era, its population was barely one-tenth of what it is at the present time. The national wealth in that day was probably little, if any, more than one per cent of the five hundred billions which now represent the estimated value of our visible resources.

In the early 1830's the Allegheny Mountains were the frontier. There was a thin fringe of settlement on the Gulf Coast, a few footholds on the Pacific Coast and scattered, meager outposts in the country tributary to the Great Lakes and the navigable waters comprised in the Mississippi-Ohio-Missouri River system. In the next few decades, however, the building of railroads changed all this. The lines were pushed forward far in advance of movement of population, and were the actual physical means by which the great inland empire of America was created, stretching from the Allegheny Mountains to the Coast Range.

Today, with something over 6 per cent of the world's

* *A Paper presented to the Atlantic Deeper Waterways Association.*

population, we have about 40 per cent of all its railroad facilities. We are more dependent upon rail transportation than the people of any other country, and use vastly more of it, measured in ton-miles per capita, than the people of any other nation.

We are ever mindful of the value of the railroads in the upbuilding of the nation. Neither this generation, nor the next, nor probably the generation after that, will see their utility greatly curtailed. On the contrary, it seems not merely probable but practically certain that the need for the services of the railroads, as the great bulk carriers of the country, will continue to increase, indefinitely, with the continued growth of the manufacturing industries, mining, agriculture, commerce and population.

Wholesale vs. Retail Carriers

Several years ago our Vice-President in Charge of Operation, Mr. Elisha Lee, in addressing a conference of automotive engineers, expressed the opinion that the railroads were destined to be the wholesale carriers of the nation, and motor vehicles the retail carriers. The real problem as between railroads and motor vehicles, he said, was one of co-ordination rather than of competition. Nothing which has happened since supplies any ground for altering those conclusions.

The entire trend of railway development in recent years has been towards heavier locomotives, larger cars, stronger bridges and other structures, heavier tracks and larger terminals. All of this fits the railroads better and better to render long distance mass transportation service. It fits them less and less to furnish short distance local service. In the bulk field and long distance, they are supreme, and will continue to be so.

Motor vehicles, on the other hand, with their greater flexibility of operation and smaller size, and particularly their capacity for making door-to-door delivery, whether of freight or passengers, are supremely fitted for the short distance lighter forms of service.

In so far as short distance hauls are concerned, less than carload freight and local service on lightly patronized lines is gravitating from the railroads to the motor vehicles. We may as well concede that this is largely a natural process and economically sound.

In combination with this form of traffic, there is a wonderful field for both trucks and busses to act as feeders of the railroads to supply service in sparsely settled territories not warranting the construction of rail lines, and to act as connecting links between existing railroads. This, too, is all in the direction of sound development, and is based upon good business principles. Instead of injuring the railroads or impairing their capacity for rendering service, it will actually help them and supplement and improve the service which they are capable of furnishing to the public.

Unfortunately, however, a good many efforts are now being made to extend the service of trucks and busses into what should be regarded as the permanent railroad field—that is the longer hauls and heavier traffic. Particularly is that so, just at present, in the case of passenger bus enterprises.

Federal Regulation Held Inevitable

No one can say with certainty what is the sound limit of distance for bus operation. Doubtless that varies in different localities. In some sections where the traffic does not warrant the building of railroads, quite long bus routes are no doubt justified. In heavily developed territory, however, where perfectly adequate service is being rendered by the railroads, it is very questionable whether directly competitive bus routes should, in the public interest, be allowed at all.

Commercial motor transport, both of freight and passenger, is here to stay. It has a tremendous field of utility, and no interests should be readier and more willing than the railroads to admit that fact and co-operate in its proper development. Its future possibilities for rendering real service to the public are immense, and in fact the volume of service even now being rendered is very large and important. That being the case, it is impossible to escape the conclusion that this new means of transportation must do what the railroads have done; namely, submit to Federal as well as State regulation in order that the entire transportation machinery of the country may be co-ordinated and controlled properly, which can only be done by making both amenable to the same regulative agencies.

At the present time, about three-quarters of the States have provisions, varying greatly of course in their adequacy, for regulating motor truck traffic within their boundaries. A little more than half of the States have provisions, more or less adequate, for regulating passenger transportation by motor, within their boundaries. But interstate transportation by motor vehicles, of either freight or passengers, is entirely unregulated for the reason that the individual States are without authority with respect to it, and the Supreme Court has ruled that under existing laws the Interstate Commerce Commission has no power to act. As you are probably all aware, a series of hearings are now being held, under the auspices of the Interstate Commerce Commission, to gather the facts with regard to the situation, and no doubt for the purpose of making definite recommendations.

Uneconomic Competition Always Wasteful

The Transportation Act of 1920, under which the railroads are operating, specifically states that it is the policy of Congress to encourage sound transportation and strengthen and fortify the rail carriers. Under one of its provisions, however, no railroad can build a single mile of new line without approval by the Interstate Commerce Commission, and a finding by the Commission that the building of such line is necessary for the public service and convenience. The reason for this provision is that every unnecessary facility or duplication of already existing and adequate facilities, involves an economic loss in construction and operation which in the long run is a charge upon the public. The law forbids such competitive waste between railroads. It, therefore, seems reasonable the same limitations should apply to the establishment of competitive motor transport lines where the existing railroad facilities and service are already adequate to the public needs.

This is certainly what we are coming to unless we wish to court disaster. It is believed manufacturers of trucks and busses, and the responsible operators of these vehicles, will welcome the establishment of sound regulation, because in the end it will place their business upon a safe and permanent footing, and forestall many of the unthinking from rushing headlong into ventures involving losses in the end.

We have had thirty-eight years of experience with Federal regulation of railroads. In that period the regulative authorities, the railroads and the public, have all learned a great deal about the true functions of regulation, and the aims which it should seek to obtain. The motor vehicle operators have the advantage of coming into the field with all of this experience, much of it painfully acquired, available for their benefit in framing a system of regulation which should be constructive from the start, instead of, as was the case with the railroads, starting out by being punitive and restrictive.

The Need for Adequate Taxation

To a sound system of regulation we must, of course, add the necessity for adequate taxation. The highways are built by public funds raised by taxation, and incidentally I may point out that the railroads, paying taxes now at the rate of more than one million dollars a day, are indirectly probably the chief supporters of our highway systems and their extension. Going back ten years, railway taxes for 1916 amounted to approximately $430,000 per day. Every year since then they have increased over the preceding year. In the last five years, a period of great economy in railway management and operation, the daily tax bill of the railroads has increased on an average of more than $47,000 from year to year.

Parenthetically, it is interesting to note that regulation of vehicles on public highways is in no sense a new thing. Three hundred years ago, in England, it was found necessary to restrict the horse-drawn vehicles of that time. In 1621, during the reign of King James I, four-wheeled vehicles and the hauling of more than one ton at a time was forbidden because such vehicles or heavy burdens "so galled the highways and the very foundation of the bridges that they were public nuisances."

Again, when it was contemplated to increase the speed of stage coaches during the early 40's by a process of relaying horses at frequent intervals, a bill was introduced in the New York Legislature opposing such procedure upon the argument that stage coaches passing each other at such high rates of speed (six or eight miles per hour) would create a hazard of such momentous proportions as to be greatly deplored.

Privately Operated Motor Vehicles

My discussion of the subject has been confined, as I assume it was intended to be, to commercial motor transport. I am, of course, aware of the fact that privately owned and operated vehicles carry more passengers and freight than those operated for hire.

Thus far the private automobile has doubtless affected railroad traffic more than the motor bus, but its net effect certainly cannot be justly regarded as detrimental. It has, to be sure, taken away much traffic from lightly patronized local trains, and in that manner rendered still more unprofitable the operation of many trains which were already running at a loss. On the other hand, it has frequently made possible a reduction in the number of such unremunerative trains so that real saving resulted.

Then, too, the private automobile has been by far the greatest factor in bringing about the immense exodus of population into the suburbs and country from the congested districts of our cities. It has made it practicable for people of moderate means to live considerable distances from suburban and country railroad stations. In that manner, it has undoubtedly built up travel on certain suburban lines.

Motor trucks, owned and operated by large industries, for their own use, are certainly carrying much freight which was formerly shipped by railroad. But, on the other hand, less than carload freight, particularly on short hauls, is not usually very remunerative to the railroads and often involves a distinct loss. At the same time these trucks are playing an immensely important part in the success of great industries, which employ them, and which for their operation and the marketing of their products require a constantly increasing volume of long-distance bulk transportation service, such as the railroads can best render. Therefore, the privately owned automobile or truck is helpful. They are bringing us, in the long run, far more than they take away.

The United States really has two transportation systems. One is the railroads and their equipment. The other is comprised in the improved highways and the motor vehicles operated on them. A comparison is interesting.

The railroads have 251,000 miles of line. Improved highways are estimated at 495,000 miles. Railroads have 2,440,000 freight cars, while on the highways there are 2,500,000 motor trucks running. The railroads have 57,000 passenger cars, while nearly 18,000,000 automobiles and 70,000 motor busses are furnishing highway transportation for passengers. Without any question, the number of passengers carried one mile, annually, in motor vehicles far exceeds the passenger miles of the railroads.

Including their locomotives, the railroads have altogether about 2,600,000 units of equipment, while motor vehicles of all kinds on the highways number more than 20,000,000.

The investment in railroads and their equipment and property of every sort may be placed at about $25,000,000,000, and the investment in motor vehicles and highways is estimated at the same round figure. The annual cost to the public of operating the railroads—that is, what the public pays in rates and fares—is something over six billions of dollars. The annual cost of operating and maintaining the highway system of transportation, including the vehicles and the highways themselves, is placed at over twelve billions, or double the cost of railroad service.

Trend During the Last Five Years

It is interesting to note the changes that have taken place in five years. Five years ago the railroads had about 2,000 more miles of line than at the present time, but their investment was some three billions less, on account of improvements that have since been made on existing lines, and replacement of equipment with better type. The number of units of railroad equipment five years ago, however, was substantially the same as at present. On the other hand, the investment in motor vehicles and highways has nearly doubled in five years. The total number of motor units has more than doubled and the annual cost of motor operation and maintenance, including the highways, has increased about 135 per cent.

Altogether the situation is full of interest. There seems to be no limit to the use of transportation by the American people. Our sound national common sense should save us from excesses and preserve a proper balance between the agencies by which this indispensable service is rendered.

B. & O. Extends Service to Brooklyn

The Baltimore & Ohio Railroad will extend its trainside motor coach connection by starting a line of motor coaches from its new passenger station in the heart of Brooklyn to meet all trains at Jersey City Terminal. The new passenger station is in the center of the business district of Brooklyn and close to Borough Hall, being located on the ground floor of the Central Building on Joralemon street, near Court street.

The opening of the new station will mark the first time that a trunk line railroad will have a passenger station in Brooklyn. Besides the regular ticket office, every facility will be provided for the convenience and comfort of passengers, including the new feature, made possible by the motor coach service, of checking hand-baggage so that passengers are relieved of the care of it until it is delivered to them in the train at the Jersey City Terminal. This arrangement, which has been in use in the established Manhattan routes of the trainside motor coaches of the Baltimore & Ohio since the service started last August, has been working smoothly and seems to be much appreciated by patrons.

New York Central New Electric Freight Locomotives

Two-Unit Locomotive Designed to Haul 3,000 Ton Train at 32 Miles an Hour—The Two Sections Enabling It to Round Curves More Easily

The first of the new Class "R" road freight electric locomotives being built by the General Electric Company for the New York Central Railroad for service in the Electric Division between Croton, or North White Plains, and New York City, have been delivered and the locomotive was recently given the test of pulling a freight train approximately one mile long and consisting of 108 cars, from Croton to High Bridge on two round trips.

While not equaling record train lengths, is represented one of the longest freight trains ever operated in New York City limits, and was equivalent to a pull of 3,006 tons.

Edwin B. Katte, Chief Engineer of Electric Traction, was in general charge of the design, construction, and testing of these locomotives.

The Class R locomotive is the first locomotive designed for road freight service on the New York Central Lines. It is intended for general freight haulage at New York. The first locomotive, No. 1200, of the initial order of two locomotives, was received at Harmon Shops early in September and put through an acceptance test on the Hudson side of the Electric Division. It is the intention that all through freight in the Electric Division and on the West Side freight tracks in the City of New York will be handled by locomotives of this type.

The R locomotive differs from all previous New York Central electric locomotives in being built in two nearly identical units. The two units are connected by a special coupling and can be separated for shop purposes but are numbered alike and will not be separated in service. Each unit has a complete equipment of collectors, motors, and control, and the two units are operated from one controller as are two multiple unit cars.

The principal dimensions are as follows:

Length: Coupler faces	68 ft.-2 in.
" Each cab	29 ft.-0 in.
" Kingpin centers, each unit	16 ft.-0 in.
" Spread of third rail shoes about	49 ft.-0 in.
Wheelbase: Total	55 ft.-3 in.
" Each unit	24 ft.-3 in.
" Truck	8 ft.-3 in.
Height: Floor	5 ft.-4¼ in.
" Roof	12 ft.-7 5/16 in.
" Trolley, locked down	14 ft.-7 in.
Width: Cab sheets	9 ft.-10 in.
" Overall (eaves)	9 ft.-11½ in.
Wheel Diameter:	44 in.

The designed weight was 170 tons, all on drivers. The actual weight by scales is 353,600 pounds, 44,200 pounds per driving axle.

Eight traction motors of standard railway type, with commutating poles and forced ventilation, are mounted on the axles. The motors are designated as GE-286 A, and are identical, except gear ratio, with those used on the Class Q switching electric locomotives and to be used on the oil-electric locomotives now under construction. The pinion on the armature shaft has 20 teeth and the gear on the axle 69 teeth, giving a ratio of 3.45, as compared with 4.235 on the Q locomotive. The motors are insulated for 1,500 volts for possible future use, two in series.

The four motors on each unit are connected in series, series-parallel, and parallel, at successive controller positions. At any running position, a separate handle on the controller can be moved to either of two positions, known as FS 2 and FS 3, to obtain higher speed by weakening the motor fields by means of inductive shunts.

The GE-286 motor is rated at 415 horsepower (575 amperes) on the standard one-hour basis, with a temperature rise of 120 degrees Centigrade, and a voltage of 600. The continuous rating is 332 horsepower (460 amperes). The one-hour rating of the locomotive is 3,330 horsepower. At 20 per cent adhesion between wheels and rails the locomotive develops (based on 170 tons weight) 68,000 pounds tractive effort, and the speeds to which this tractive effort can be exerted at 575 volts, are: series, full field, 4.0 miles per hour; series parallel, full field, 9.6 miles per hour; parallel, full field, 20.0 miles per hour; FS 2, 22.5 miles per hour; FS 3, 24.8 miles per hour.

The control apparatus is of the electro-pneumatic type similar to that on the later multiple-unit cars, in which the power for closing contractors, throwing reverses, etc., is supplied by compressed air, controlled by solenoid-actuated valves. All current for control, lights, etc., is taken from a storage battery which is charged in series with the blower motors.

The locomotive is equipped to operate on standard New York Central third rail, on overhead third rail, and on the contemplated overhead construction on the West Side tracks.

The most notable mechanical feature of the locomotive is the use of integral steel castings for the cab underframe and the truck frames. These castings simplify the construction by eliminating great numbers of bolts, rivets and small parts.

The cab of each unit is divided by a transverse partition into an operating cab at the outer end, and apparatus space occupying the remainder of the cab. An aisle extends along each side from a door in the partition to a middle door at the other end for communication between units. The blowers, air compressor, etc., are located on the floor between these aisles, and the control apparatus (circuit breaker, contactors, relays, reverser, series-parallel switch, etc.) is arranged in two rows in a compartment next to the operating cab, and is accessible either from the outer aisles or from a short center aisle opening into the operating cab. The rheostats are located on the floor in this compartment and ventilated through chimneys to the roof.

The locomotive is capable of operating with a train, on a curve of 230 feet radius, and of running at a speed of 60 miles an hour. It was designed to haul a train of 3,000 tons of cars, of which 75 per cent are empties and 25 per cent 50-ton loaded cars, at 32 miles per hour with voltage at 575. The service capacity of the locomotive was defined in the specifications by a requirement that in a continuous series of runs between Seventy-ninth street (West Side) and Harmon, hauling the train above mentioned, making four intermediate two-minute stops on each trip, accelerating at 20 per cent adhesion, and having a layover of 20 minutes at each terminal, with voltage at 575, the temperature rise in the motors should not exceed 140 degrees Centigrade measured by resistance, or 120 degrees Centigrade by thermometer.

In the acceptance test of locomotive to determine whether the locomotive conformed to the requirement of the specification. A train of 108 cars, including cabooses, with the proper proportion of loads and empties, and weighing 3,006 tons, was assembled. A caboose contain-

ing instruments to indicate and record voltage, amperes and miles per hour, was coupled to the locomotive and the instruments connected into the locomotive circuits by cables carried temporarily over the roofs. It was intended to run three round trips with this train in about seven and one-half hours, but due to accidental uncoupling of cars and other operating delays the test was terminated after nine hours near the end of of the second round trip, after making a train mileage of 95. The number of stops, exclusive of terminals, was 17. The maximum speed was 34½ miles per hour. The amount of power consumed by this locomotive in hauling the 108-car train under the described test conditions was, in electrical units, 26.3 watt hours per ton mile.

The maximum motor temperature rise observed was 90 degrees Centigrade, which, taking into consideration all the conditions of the test, indicates that the temperature rise would be well within the limits of 140 degrees named in the specifications.

Excellent Condition of Railway Equipment

The railroads of the country, while making new high records in loadings, are maintaining their equipment in such excellent condition that on October 23 they had available 79,016 surplus cars. The number of freight cars in need of repair on October 15 was the lowest in five years. On the same date there were 4,242 serviceable locomotives in storage.

Motive Power Condition

Class I railroads on October 15 had 9,290 locomotives in need of repair or 14.9 per cent of the number on line, it is shown by reports filed with the Car Service Division of the American Railway Association.

This was an increase of 401 locomotives over the number in need of repair on October 1, at which time there were 8,889 or 14.2 per cent.

Of the total number of locomotives in need of repair on October 15, 4,926 or 7.9 per cent were in need of classified repairs, an increase of 223 compared with October 1, while 4,364 or 7 per cent were in need of running repairs, an increase of 178 compared with the number in need of such repairs on October 1.

Serviceable locomotives in storage on October 15 totaled 4,242 compared with 4,680 on October 1.

Freight Car Condition

Fewer freight cars were in need of repair on October 15 than at any time in the last five years, according to the Car Service Division of the American Railway Association.

Reports just filed showed 145,327 freight cars in need of repair or 6.3 per cent of the number on line.

This was a decrease of 2,935 cars under the best previous record, established on December 15, 1923, when there were 148,262 cars or 6.5 per cent. It also was a decrease of 3,751 cars under the number in need of repair on October 1 this year.

Freight cars in need of heavy repair on October 15 totaled 110,792 or 4.8 per cent, a decrease of 3,375 cars compared with October 1, while freight cars in need of light repair totaled 34,535 or 1.5 per cent, a decrease of 376 cars compared with October 1.

Class I railroads on October 23 had 79,016 surplus freight cars in good repair and immediately available for service, the American Railway Association reported.

This was a decrease of 7,916 cars compared with October 15, at which time there were 86,932.

Surplus coal cars in good repair on October 23 totaled 13,997, a decrease of 2,456 within approximately a week, while surplus box cars totaled 43,421, a decrease of 4,874 cars during the same period.

Reports also showed 11,635 surplus stock cars, a decrease of 107 cars below the number reported on October 15 while surplus refrigerator cars totaled 3,403, a decease of 714 cars within the same period.

Mogul Type Locomotives on British Railways

By ARTHUR CURRAN

Students of American railroad history are aware of the fact that, many years ago, it was a common practice to locate locomotive cylinders in an inclined position, and that this practice was discontinued as soon as it was discovered that the horizontal position was more desirable from every point of view, including that of appearance. With certain obvious exceptions, the standard American practice has prevailed to this day, and is not likely to be changed.

It is a matter of some surprise, therefore, that one of the larger British railway systems—the London, Midland & Scottish—has come out with a Mogul which, though not freakish from any other point of view, has its cylinders cocked up at a most amazing angle.

The 2-6-0 type was tried in England many years ago, but it was not until 1899 or thereabouts that it appeared in considerable numbers. At that time, a shortage of motive power, with which domestic builders could not cope, drove three of the British railways into the American market and brought Baldwin and Schenectady Mogul engines to England. For some cryptic reason, these American-built engines were not liked, and, after being in service for some years, were scrapped.

In due course, however, the idea was taken up again; but by British builders. At the present time, Mogul engines are to be found on all of the leading British railways. They have given a good account of themselves and are well liked by crews. They are used in "goods," excursion, fast freight and express passenger service—the latter on hilly sections.

Up to the construction of the L. M. S. engines above mentioned, the only Moguls with inclined cylinders were a few of the old London, Brighton & South Coast, a relatively small railway now owned by the Southern. In this case the cylinders were but moderately inclined as compared with the L. M. S. design. The object in view in the construction of British Moguls is the provision of a handy engine, powerful for its weight, moderate in cost and easy to handle. Having made these points clear, we may proceed to a consideration of examples.

Among the more meritorous designs, that of the Great Western Railway is marked by a rugged simplicity and absence of "doodads." The first of these standard Moguls appeared in 1910, the cylinders being 18½ x 30 inches, drivers 68 inches in diameter, working pressure 200 lbs., and tractive effort 25,670 lbs. These engines have superheaters, piston valves and the American style of cylinder saddle. Successive orders have brought the number of these Moguls to a considerable total, though the exact number is not easy to determine as it includes some old 2-6-0 engines with inside cylinders. However, there must be several hundred of them by this time; and the way they go up hill and down dale and around curves when in passenger service is exhilirating to a degree!

A somewhat more pretentious design is that of the Southern Railway (England). The cylinders are 19 x 28 inches, drivers 66 inches in diameter, working pressure 200 lbs., and weight, including tender, "98 tons 13 cwts.," which being expressed in British terms, you may work out for yourself, remembering that the British ton is heavier than ours. The machinery and motion—the latter outside

—are very beautiful, and the cross-heads are of the underhung type, suspended from guides of the single-bar pattern. The boiler has a coned barrel and a Belpaire firebox, but is provided with a centrally-located dome, and thus differs from the G. W. boiler which is domeless. This class of engines has been in service since 1917 and is highly spoken of by those concerned with it. There are 55 engines in the class, and they are assigned to the various kinds of service mentioned hereinbefore. As an old-time American railroader would say: "They get over the road." I must not forget to mention that they have superheaters, piston valves, and a very good front-end of ample size to prevent trouble with bad coal. Years ago, smoke-boxes on British locomotives were too small.

On the London & North Eastern Railway the Mogul type has been developed on a grand scale. This development has its inception on the old Great Northern Railway (England) where the type first appeared in moderate dimensions, was followed by a larger version, and finally blossomed forth as a three-cylinder affair, the latest examples of which have a very nice cab with two side-windows (on each side). As, however, these three classes have been described at length in various railway periodicals, it is unnecessary to review the dimensions here. It is sufficient to remark that they have been "put through their paces" and found satisfactory, especially during periods of abnormally heavy traffic, when numbers of handy and good "all-around" engines are needed.

This brings us back to the L. M. S. Moguls, which, it is stated, are "mixed-traffic" engines; and to the question of how they are going to do their "mixing" any better by

Standard Mogul Type Locomotive Great Western Railway, England

having their cylinders cocked up in the air like telescopes! Certainly, the clearances on the road should be sufficient to allow an orthodox arrangement of cylinders on any type of engine; and the ancient myth that inclined cylinders give more power was exploded years ago.

The L. M. S. is a pretty big combination, however, and has suffered from lack of co-ordination and a definite motive power policy. It is stated that the new Mogul class was designed some time ago—in which case a modification of the cylinders would, it seems, have been feasible. As it is, the class is a curious mixture of modern and outmoded practice, and has no relation whatever to the immense assortment of locomotives which constitute the power of the L. M. S. For some time past, the road has been subjected to criticism along these lines, and the advent of the "mixers" ought to give a fillip to the proceedings!

An interesting comparison with the British Moguls is furnished by Class F-1-2 of the Pennsylvania Railroad, built at Altoona in 1898. This Mogul has cylinders 20 x 28 inches, 62 inch drivers, weight without tender of 145,000 lbs., working pressure 185 lbs., and tractive effort of 28,400 lbs. On low grade divisions one of these engines has handled trains up to 2,700 tons in weight, steaming freely and making good time.

As this class achieved such results with slide valves and a moderate steam pressure, and without the aid of a superheater, it appears to be entitled to a few kind words!

Some of these F-1-2 locomotives went into passenger service in the course of time, where they rendered good service and did plenty of "mixing" with horizontal cylinders!

Among general remarks may be included the statement that the 2-6-0 wheel arrangement is an old one, and that its name has been used in a rather free and easy manner by inexperienced persons to describe any engine from a yard "goat" to a Mallet pusher! For some esoteric reason, the designation "Mogul" appeals to the popualr imagination, whereas Mikado—really a much more impressive name—leaves people "cold."

I am reminded of the lady who once told me that she liked the name Woodruff. She could not advance any logical reason for this preference, but merely clung to it desperately. Perhaps some day an enthusiastic citizen will bestow the name "Mogul" on a taxicab! It will be just as logical as many other uses to which this obviously fascinating name has been applied.

A photograph of the standard G. W. R. Mogul is presented herewith.

Mud Ring and Flue Sheet Drilling Machine

To meet the demand of the railroad shops for heavier equipment required in the building of the modern larger type locomotive, the Foote-Burt Company has recently designed a drilling machine, which they call the No. 3 Mud Ring and Flue Sheet Drilling Machine, regularly equipped with four No. 30 heads.

This machine is built to drill the rivet holes around the fire box mud rings, and the flue holes in boiler flue sheets.

The long travel of the table, the back and forth adjustment of the spindles, as well as the in and out adjusmtent of the spindles, allows the drilling of large flue sheets in one setting.

The spindles overhang the finished edge of the base so that mud rings can be bolted to this finished edge by means of three "T" slots running horizontally for drilling the rivet holes. The two further outside knees that support the table are fixed, but the three center knees are adjustable back and forth in case they interfere with the claiming of mud rings. Of course, when drilling flue sheets all knees are securely doweled in position to form the bearing for the table.

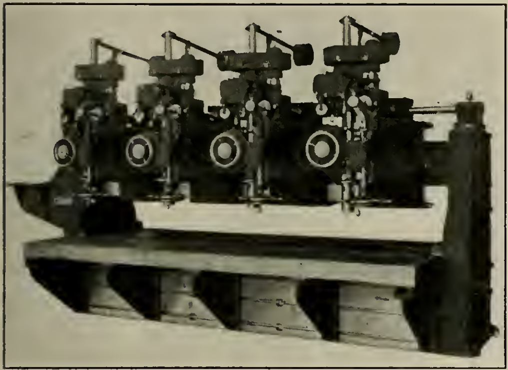
This machine is so arranged that a pit can be placed in the floor flush with the front finished edge of the base to allow the mud rings to project down in same for drilling the rivet holes. The size of the pit is naturally governed by the size of the mud rings being operated on.

The machine can be arranged for either belt or motor drive as desired. The power is transmitted through a heavy horizontal shaft where the drive is taken for each head through bevel gears. From there power is transmitted through a vertical shaft in each head through spur gears direct to the spindle. All gears subject to heavy duty are made of high grade steel and all shafts are mounted on bronze bearings.

Each head has a drilling capacity of 3½ in. in solid steel, or 7 in. using Flycutter. Each head is adjustable along the rail, the minimum center distance between spindles being 24 in.; the maximum distance between the two outside spindles, 123 in. The spindles also have an in and out adjustment of 18 in. All hand wheels controlling

the adjustments of the heads are located at the front of the machine within easy reach of the operator. This also includes the hand wheel which controls the spindle itself.

Each head is equipped with three quick feed changes independent of each other. The speed changes are accomplished by the cone pulley and back gears when machine is arranged for belt drive, or by variable speed motor when arranged for motor drive, but speeds in each head cannot be changed independently.



Mud Ring and Flue Drilling Machine

The spindles are made of high carbon steel and have long bronze bearings in the spindle sleeve. The spindles sleeve is also made of steel, and the double rack cut solid. This double rack feature is a "Foote-Burt" patent, and approximately doubles the strength of the down pressure, which is enormous when these large sized drills are used.

Care has been taken in the design of this machine to make it as rigid as possible, the uprights being securely bolted to the base in an "L" shaped pad. The cross rail carrying the heads is a box type and is placed in large slots in each of the uprights and securely bolted from three directions. Each head slide is wrapped completely around this box type cross rail and securely gibbed to obtain the maximum amount of bearing on the cross rail.

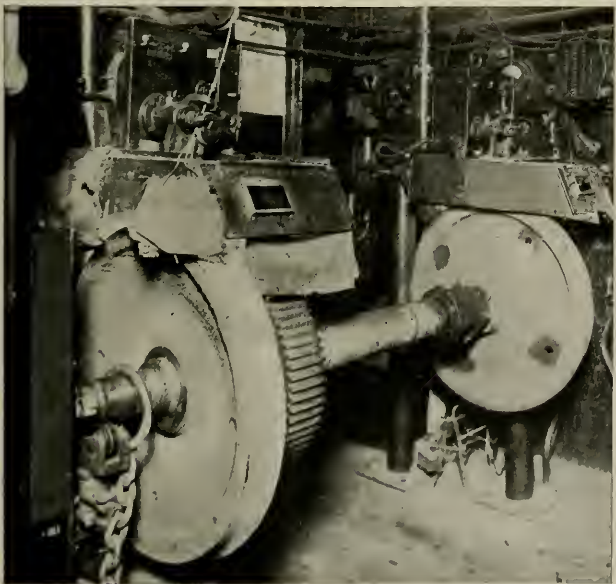
The table has a working surface of 75 in. x 144 in., and provided with in and out adjustment of 60 in., and should be placed at the extreme rear position when drilling mud rings.

Other details of the machine are given in the following table:

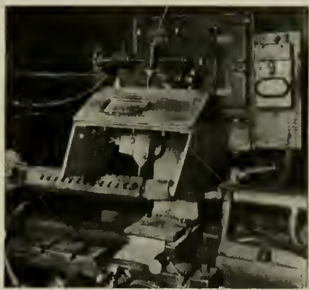
Capacity of each spindle in solid steel	3½ in.
Capacity using flycutters	7 in.
Minimum center to center of spindles	24 in.
Maximum center to center of outside spindles	123 in.
Maximum distance nose of spindle to top of table	21 in.
In and out adjustment of spindles from main rail	18 in.
Working surface of table	75 in. x 144 in.
Table provided with in and out adjustment	60 in.
Center of spindle clears front edge of base, when in the extreme front position	8½ in.
Distance between housings in clear	144 in.
Spindle, diameter bearing in sleeve	3 in.
Spindle, diameter driving end	2⅞ in.
Spindle, diameter nose	4-15/32 in.
Spindle, sleeve diameter	4½ in.
Spindle, sleeve length	24 in.
Spindle, vertical travel	14 in.
Spindle, driving gears	3 in. face, 4 pitch
Spindle, Morse Taper	No. 6
Spindle, Feed changes.. .008-.014 and .020 ins.	per Rev.
Speed changes	40 to 120 RPM

Eliminating Railway Replacements by Automatic Welding

Automatic arc welding has found a particularly good application in street railway repair shops repairing worn flanges of car wheels, and has eliminated scrapping such equipment and the excessive cost of replacements.



Showing Worn Car Wheels in Position to Be Welded



Slack Bar in Place on Lathe Ready to Start the Welding of Seam.

Instead of discarding car wheels whose flanges have become worn and which have been machined down several times, these wheels are built up by welding with a Westinghouse Auto-Arc. The worn wheel is placed in an arrangement that consists of two stationary pedestals on which the car wheels are placed, free to rotate. The wheels are driven by an attachment to the axle shaft, through a reduction gear which in turn is driven by a small suitable size motor. The Auto-Arcs are mounted on a stationary pedestal and free to swing as directed by the operator. As the wheels revolve the auto arc performs its work, at a peripheral speed of about 10 to 12 inches per minute. A set of car wheel flanges can thus be built up in about 2½ hours.

The welding of brake equalizers or slack bars, is another use for the Auto-Arc in the railway shop. In this instance the Auto-Arc is mounted on the carriage of a lathe, so that it can be moved along the work either by hand or by lead screw, with an adjustable driving speed.

This brake equalizer which consists of four flat perforated bars forming a hollow box is placed in the lathe and the sides are temporarily held in place by a clamping device. The operator starts the machine, the work remaining stationary in this case, and the welding is performed as the Auto-Arc moves along the seam of the box.

Bituminous Shipments Heaviest Since 1920

Bituminous coal shipments this fall are larger than they were at this season of the year in the past five years, according to reports filed by the railroads with the Car Service Division of the American Railway Association.

This heavy fall movement is being handled by the railroads without transportation difficulties, however, the railroads for the week ended on October 16 having had a daily average of 16,453 surplus open top cars in serviceable condition. A few local car shortages in isolated instances have been reported but these have been of short duration.

From September 1 to October 16 this year, loadings of bituminous coal totaled 1,423,135 cars, or 81,183,000 tons, an increase of 50,614 cars or 3,802,000 tons over the same period last year. For the week ended on October 16, bituminous coal loadings amounted to 217,478 cars of 12,376,000 tons, which exceeded the corresponding week in any of the previous five years.

From September 1 to October 16 this year, loadings of anthracite coal totaled 273,226 cars or 14,367,000 tons. For the week ended on October 16, it amounted to 41,087 cars or 2,093,000 tons, the highest for the same week in any year since 1917.

Movement of coal by water to points on the Great Lakes has been especially heavy this year, bituminous coal dumped into vessels at Lake Erie ports totaling 24,270,937 tons from January 1 to October 16. Bituminous coal dumping this year exceeds the corresponding period last year by more than 2,000,000 tons.

Shipments by rail of anthracite coal to New England is now the greatest in six years, it having amounted to 23,184 cars for the week ended on October 9. This brought to 123,870 cars the total anthracite shipments sent by rail to New England since January 1 this year.

All rail bituminous coal shipments to New England from January 1 to October 9 this year total 116,710 cars, which exceeds the corresponding period in both 1925 and 1924. For the week of October 9, the bituminous coal movement to New England amounted to 17,883 cars.

There were also 8,345,670 gross tons of coal shipped by water to New England from January 1 to October 1.

More bituminous coal is now being exported from Atlantic ports than at any time in the last ten years. This increased demand for American coal has been stimulated by the strike of English miners. During September bituminous coal dumped into vessels at North American ports for export totaled 2,472,547 gross tons. This brought to 10,359,347 tons bituminous coal exports for the first nine months this year.

The increase in bituminous coal production for the period September 1 to October 16 over the same period of 1925, approximates very closely the total volume exported during the same period.

For the week ending October 30, the National Coal Association estimates a production of 13,125,000 tons. Only twice before—since December, 1920—has bituminous production exceeded 13,000,000 tons in a week.

The Pere Marquette Railway Has Placed in Service 350 New Automobile Cars

The Pere Marquette Railway recently placed in services 350 box cars to serve the automobile and furniture interests. The new cars are being placed in international service. The cars are 80,000 lb. capacity, of the steel frame, single sheathed type. They are provided with staggered doors with 10 feet clear opening. Hutchins all-steel roofs and ends, underframes and superstructure of latest A. R. A. design modified to suit extra width of these cars.

The cars are 40 feet 6 inches long, 9 feet 2 inches wide and 9 feet 2 inches high inside. Maximum over all width is 100 feet 8¾ inches. Hoisting facilities consist of chain fall loops riveted to steel car lines on every other carline in center of car and on all carlines near top side plate of sufficient strength to carry a load of 2,000 lbs. With this arrangement loops, it is possible that lifting force can be applied with block and tackle from any angle or direction and at any place within the car.

The center sills of these cars consist of 2, 12-inch A. R. A. type "I" beams 40.3 lbs. extending through car from end to end with a 20-inch by ¼-inch cover plate giving cross section area of 28.7 square inch. The side sills are of 7-inch channel 18.8 lbs. per foot. Body bolster is of box sections having ⅜-inch pressed steel diaphragms flanged 3½-inch all around and placed 11 inches back to back. Top and bottom cover plate extend from side sill to side sill. The diaphragms are provided with holes for hold down chains used in securing cars to carry ferry decks.

These cars are especially suited for automobile body loading on account of width as it is possible to load bodies crosswise of car instead of angle loading, thereby gaining two bodies over former type of car used on this road.

Midwest Power Conference

The 2nd Midwest Power Conference will be held at the Coliseum in Chicago, February 15-18, inclusive, 1927. Plans already made indicate that this meeting will be of great importance to power engineers and managers throughout the country. The valuable contributions to power engineering progress given by the first Conference are still fresh in the minds of those who attended, and it is planned to continue the sessions on the same comprehensive and valuable basis as before.

This Conference is sponsored and endorsed by the local sections, regional and professional divisions of the following societies: American Institute of Electrical Engineers, American Society of Mechanical Engineers, American Institute of Mining Engineers, National Electric Light Association, Western Society of Engineers and National Safety Council.

The general plan of the 1927 conference will be to deal with the larger aspects of power utilization in the field of industry. Five sessions have been planned; the opening session February 15; two industrial sessions on February 16; the Gas Power session February 17, A. M., and the Fuel session February 17, P. M. Friday, February 18 will be devoted to inspection trip to important plants in the Chicago territory. The papers tentatively outlined will be presented by well known authorities on the subjects mentioned and ample opportunity will be offered for discussion so that the greatest benefit will result.

During the same week and in the same building, Chicago will hold its Second Midwestern Engineering & Power Exposition. This combination of a Power Show and a Power Meeting gives ample opportunity for the engineer to utilize his time to the best advantage in order to secure the best thoughts on important power subjects.

The International Railway Fuel Association

The International Railway Fuel Association has established an office in the Railway Exchange Building, 80 East Jackson Boulevard, Chicago.

This office will be in charge of Mr. L. G. Plant, who was recently appointed Secretary-Treasurer, succeeding Mr. J. B. Hutchinson, who has held this position with an office in Omaha, Neb., for several years.

The increasing importance of the railway fuel conservation and growth of the International Railway Fuel Association as the most active agency in this field, which naturally centers in Chicago, justifies the Association in establishing a permanent office where periodic meetings of its committees can be held throughout the year and where its annual convention is held regularly during the month of May.

The next annual convention of the International Railway Fuel Association will be held in Chicago, May 10th to 13th inclusive. Following the custom established by this Association prominent railway officials representing the Operating, Mechanical, Engineering, Accounting and Purchasing Departments have been asked to address the Convention from the standpoint of their respective departments.

All communications regarding the work of the International Railway Fuel Association, the publications of this Association, Convention program and arrangements, etc., should be addressed to 516 Railway Exchange Building, Chicago.

Triple Hopper Steel Cars of 70 Ton Capacity

The Delaware, Lackawanna & Western Railroad Company has recently placed in service 400 70-ton capacity triple hopper bottom steel hopped cars. These were built at the Berwick, Pennsylvania, plant of the American Car and Foundry Company.

Special features of the car body include the three double hoppers which are provided with extra large door openings which facilitate easy and rapid discharge of the lading.

The details of the hoppers, such as side and center hopper sheets, stiffeners, door spreaders and hopper doors are standardized and made interchangeable, thus minimizing the number of parts for repairs.

The hopper doors are of corrugated steel, each set operating independently.

The sides of the car are arranged with stakes on the inside of side sheet permitting an increased loading capacity over the conventional type of hopper car with stakes outside of the side sheets.

There are ten pressed steel stakes on each side of car, two of which are secured to the center construction by means of deep gusset plates to prevent side bulging.

The sides are further reinforced by four pressed steel crossties placed near the top of sides and properly spaced to give uniform stiffness.

The trucks are A.R.A. cast steel integral journal box type with 6 x 11 in. axles.

The cars are equipped with specialties as follows:

A.R.A. Type "D" Cast Steel Couplers.

End View of Triple Hopper Steel Hopper Gear

Triple Hopper Steel Hopper Cars of 70 Tons Capacity—Built by the American Car & Foundry Company for the Delaware, Lackawanna & Western Railway

Cast Steel Coupled Yokes.
Cardwell G-111-AA Friction Draft Gear.
Carmer Latest Improved Type Uncoupling Device.
Union Centering Device.
Ajax Corrugated Steel Hopper Doors.
Enterprise Type "D" Hopper Door Operating Mechanism.
Ajax Hand Brake Mechanism.
Azee Type "K" Air Brake Retainer Pipe Valve Anchor.
Westinghouse Schedule KD-1012 Air Brake Equipment.
A.R.A. Cast Steel Integral Journal Box Type Truck Side Frames.
Cast Steel Truck Bolsters.
Barber Lateral Motion Device.
Woods Spring Controlled Side Bearings.
A.R.A. No. 2 Plus Brake Beams.
Creco 4th Point Brake Beam Supports.

The general dimensions, cubic capacity and weight are:

Length over striking plates	41 ft. 5 in.
Length inside	40 ft. 0 in.
Width over sides—extreme	10 ft. 2¾ in.
Width inside	10 ft. 1 in.
Height from rail to top of sides	10 ft. 8 in.
Capacity level full	2755 Cu. Ft.
Capacity with 10 in. Average heap	3090 Cu. Ft.
Weight	50,800 Lbs.

Strathcona Memorial Fellowship in Transportation

Five Strathcona Memorial Fellowships in Transportation, of One Thousand Dollars each, are offered annually for advanced work in Transportation, with special reference to the construction, equipment, and operation of railroads, and other engineering problems connected with the efficient transportation of passengers and freight, as well as the financial and legislative questions involved. Transportation by water, highways, or airways, and the appropriate apparatus involved, and also other general aspects of the broad field of transportation, embracing its legal and economic phases, will be included in the list of subjects which the Fellows may select for investigation and study. The holder of a Fellowship must be a man who has obtained his first degree from an institution of high standing. In making the award, preference is given, in accordance with the will of Lord Strathcona, to such persons or to the sons of such persons as have been, for at least two years, connected in some manner with the railways of the Northwest.

Applications for these Fellowships should be addressed to the Dean of the Graduate School of Yale University, New Haven, Connecticut, before March 1, on blanks which may be obtained from him. Applicants must submit with their application a brief biography, and a certified record of their previous courses of study in college or technical school, and their standing therein. They should also submit testimonials bearing upon their qualifications. A recent photograph of the applicant is requested.

Various courses of study relating to transportation along engineering, economic, and legal lines are now offered by Yale University. For greater particularity the applicant is referred to the Catalogue of the Yale University Graduate School, and especially to details found under the following groups and courses of study, viz.: Social and Political Science Government and Public Law; Civil Engineering; Electrical Engineering; Mechanical Engineering; Engineering Mechanics. Based upon the recently completed Survey of various fields of Transportation and the character of instruction and investigation therein, there may be some rearrangement of certain of the courses above cited and some amplification thereof. Pending such adjustment, the Strathcona Memorial Fellows will be entitled to pursue investigation in those aspects of transportation in which the University now offers competent guidance and supervision.

New Box Type Electric Furnace

A new box or hearth type electric furnace particularly applicable to production work in plants for the heat treating of machine parts, and to tempering lathe and planer tools, dies and punches in tool rooms is now being made.

The furnace is constructed of a shell of heavy boiler plate, riveted and bolted to a structural steel frame, and heavy front castings. The heat insulations and the heating chamber are enclosed in the shell. The entire roof is assembled in a frame and bolted to the lower portion of the shell. A feature of this construction is that the roof may be lifted and swung to one side for the inspection or repair of the linings and the heating elements.

Box Type Furnace

The direct radiating heating elements, made of nickel chromium are protected and open, and are assembled in a frame of the same metal. They may easily be removed if necessary. A cast nickel, chromium floor-plate distributes the heat evenly, protects the bottom element, and forms a smooth surface for handling the material in and out of the chamber.

By means of automatic regulation the furnaces are automatically controlled within very close temperature limits, which can be fixed as desired up to the limit of 1,850 deg. F. This automatic regulation of temperature permits economy of operation by eliminating improperly heated charges, and reducing the operator's time in attendance.

Three sizes are built having capacities at 1,500 deg. F., 100, 240 and 360 pounds of steel per hour, and with connected loads of 15, 27 and 40 kw. respectively. The smallest size uses single phase, 110-volt current; the middle size, single phase, and the largest size is designed for 1, 2 or 3 phase, 220-volt only.

Locomotives Ordered and Installed in 1926

Locomotives installed by the Class I railroads of this country in the first nine months this year totaled 1,664, according to the Car Service Division of the American Railway Association.

This was an increase of 322 locomotives over the number installed during the corresponding period last year and seven locomotives over the number installed during the corresponding period in 1924.

Locomotives on order on October 1 this year totaled 443, compared with 237 on the same date last year and 285 on the same date in 1924.

Notes on Domestic Railroads

Locomotives

The Alton & Southern Railroad has ordered one Mikado type locomotive from the American Locomotive Company.

The Denver & Rio Grande Western Railroad contemplates buying about 10 freight locomotives.

The Pennsylvania Railroad has recently let contract with the Westinghouse Electric & Mfg. Company for 4 electric locomotives.

The Terminal Railroad Association of St. Louis is inquiring for 4 locomotives boilers.

The New York, Chicago & St. Louis Railroad is inquiring for 4, pacific type locomotives.

The New York Central Railroad is inquiring for 70 locomotive tenders of 15,000 gallon capacity.

The Atchison, Topeka & Santa Fe has authorized the purchase of 10 Pacific type, 10 Mountain type, 15 Mikado type and 15 Santa Fe type locomotives.

The Norfolk Southern Railroad is inquiring for 3, consolidation type locomotives.

The Missouri Pacific Railroad contemplates buying about 45 locomotives of several types.

The Western Maryland Railway is inquiring for 20 Decapod type locomotives.

The Pennsylvania Railroad is inquiring for 75 standard type passenger locomotives. The Railroad will build 8 new electric type locomotives in its Altoona shops.

The Norfolk & Western Railway will build 30 additional 16,000 gallon locomotive tenders in its own shops at Roanoke, Va.

The New York Chicago & St. Louis Railroad has ordered 4 locomotives from the American Locomotive Company. These locomotives will be of 4-6-4 type and will have 25-in. by 26-in. cylinders and a total weight in working order of 310,000 lb.

The Pere Marquette Railway has ordered 10 Mikado type locomotives from the American Locomotive Company. These locomotives will have 26-in. by 30-in. cylinders and a total weight in working order of 312,000 lb.

The Singer Manufacturing Company has ordered one Prairie type locomotive from the American Locomotive Company. This locomotives will have 17-in. by 24-in. cylinder and a total weight in working crder of 126,000 lb.

The Louisville & Nashville Railroad has ordered 18 Mikado type locomotives from the American Locomotive Company.

The Long Island Railroad has ordered 2, 100-ton oil-electric switching type locomotive from the Ingersoll Rand Company.

The State Purchasing Department of Sacramento, Calif., has ordered one 0-4-0 type tank locomotive from the American Locomotive Company.

Passenger Cars

The Chicago & Northwestern Railway is inquiring for 8, 70 ft. baggage cars.

The Long Island Railroad has ordered 60 passenger motor cars and 30 trailer cars for electric service; 20 passenger cars for steam service and 4 combination passenger and baggage cars from the American Car & Foundry Company.

The City of Philadelphia, has ordered 150 all steel passenger cars and car trucks, six extra motor trucks and 4 extra trailer trucks, for the subway from the J. G. Brill Company, Philadelphia, Pa.

The Pennsylvania Railroad has ordered the electrical equipment for 128 multiple unit passenger cars as follows: 93 from the Westinghouse Electric & Mfg. Company, 30, from the General Electric Company, and 5 from the Brown Boveri Electric Corporation.

The New York, Chicago, & St. Louis Railroad has ordered 2 dining cars from the Pullman Car & Manufacturing Corporation.

The Union Pacific Railroad is inquiring for 5 combination baggage and automobile cars, 10 dining cars, 8 observation cars and 2 combination baggage and mail cars.

The Chicago & Northwestern Railway are to equip its 120 new passenger coaches with ball bearing wheels.

The Manila Railroad has ordered 12 passenger coaches from the American Car & Foundry Company.

The Chicago & Northwestern is inquiring for 3 combination passenger and baggage cars.

Freight Cars

The Delaware & Hudson Company has ordered 10, 30-yard extension dump cars from the Clark Car Company.

The New York Rapid Transit Corporation has ordered 2 steel box cars and 10 steel flat cars from the Pressed Steel Car Company and a motor supply car from the Differential Car Company

The Louisville & Nashville Railroad has ordered 20 air dump cars from the Koppel Industrial Car & Equipment Company.

The Chicago & Bloomington Stone Company, has ordered one 30-yard extension dump car from the Clark Car Company.

The Norfolk Southern Railroad has ordered 100 composite gondola cars of 50 tons' capacity from the Virginia Bridge & Iron Company.

The Consolidated Railroads of Cuba have ordered 6 gasoline motor cars from the J. G. Brill Company, Philadelphia, Pa.

The Chicago Indianapolis & Louisville Railway is inquiring for 6 caboose cars.

The Louisville & Nashville Railroad has ordered 250 automobile cars and 250 flat cars from the Tennessee Coal, Iron & Railroad Company.

The Carnegie Steel Company is inquiring for 8 hopper cars of 75 tons' capacity.

The Wabash Railway is building 40 caboose cars in its own shops.

The Great Northern Railway has ordered 500 steel underframes from the Pressed Steel Car Company.

The New York Central Railroad is inquiring for 60 automatic steel dump cars of 50 tons' capacity.

The Long Island Railroad is inquiring for 5 caboose cars for early delivery.

The American Steel & Wire Company has given an order for rebuilding and modernizing 40 of its dump cars to the Clark Car Company.

The Chicago & Northwestern Railway has ordered 500 stock car bodies from the Illinois Car & Mfg. Company.

The Associated Oil Company, has ordered one side dump car from the Clark Car Company.

The Standard Tank Car Company is building for its subsidiary the Standard Transit Company 200 tank cars of 10,000 gal. capacity from the Standard Tank Car Company.

The Argentine State Railways are inquiring through the car builders for 50 caboose cars.

The Standard Slag Company has ordered 7, extension side dump cars from the Clark Car Company.

The Buffalo, Rochester & Pittsburgh Railway has given an order for repairs to 500 steel hopper cars to the Pressed Steel Car Company and for repairs to 500 steel hopper car to the American Car & Foundry Company.

The Phillips Petroleum Company has contracted for 700 tank cars of 10,000 gal, capacity from the Standard Tank Car Company.

The Conley Tank Car Company is inquiring for 100 tank cars of 8,000 gal. capacity.

The United States Cast Iron Pipe & Foundry Company has ordered 6, steel gondola cars of 70 tons capacity from the American Car & Foundry Company.

The Chicago & Northwestern Railway has ordered 100 flat cars from the Bettendorf Company.

The Pere Marquette Railway has placed an order for 25 ore cars with the Pressed Steel Car Company.

The Central of Georgia Railway is inquiring for 20 underframes for caboose cars.

The Chicago, Milwaukee & St. Paul Railway is inquiring for 500 stock cars and 1,000 automobile cars.

The Gulf Refining Company is inquiring for 8 gondola cars.

Buildings and Structures

Atlantic Coast Line Railroad has awarded a contract for the construction of a multiple pit standard N. & W. type electric cinder plant at Thomasville, Ga., and for the construction of two single track junior N. & W. type electric cinder plants at Chatmar yard, Dunnellon, Fla., to the Roberts & Schaefer Company, Chicago, Ill.

The Atchison, Topeka & Santa Fe Railway contemplates the construction of water treating plant and tank at Blackwell, Okla.

The Missouri Pacific Railroad has awarded a contract for the construction of a reinforced mechanical coaling station of 250 tons capacity at Washington, Mo., to cost approximately $52,000.

The New York, New Haven & Hartford Railroad has let contracts for increasing its roundhouse at Readville, Mass.

The Central of Georgia Railway has awarded a contract for the installation of a junior N. & W. type electric cinder plant at Savannah, Ga., to the Roberts & Schaefer Company, Chicago, Ill.

The Atlantic Coast Line Railroad has awarded a contract for the construction of a 500-ton automatic electric reinforced concrete coaling station at Thomasville, Ga. to the Ogle Construction Company, Chicago, Ill.

The Illinois Central Railroad has awarded a contract for the construction of a power house at Paducah, Ky., which include coal and ash handling equipment, engine room crane to cost approximately $300,000.

The Chicago Milwaukee & St. Paul Railway plans for the expenditures of $21,000 for a water treating plant at Mobridge, So. Dak. and also one at Bristol, So. Dak.

The St. Louis-San Francisco Railway has awarded a contract for the installation of a two track electric cinder unit at Kansas City, Mo., to the Ogle Construction Company, Chicago, Ill.

The Texas & Pacific Railway has awarded a contract for the construction of a 16-stall round-house, machine shop, blacksmith and boiler shops, brick power house, brick storehouse and office buildings at Gouldsboro, La. to cost approximately $300,000.

The Chicago Milwaukke & St. Paul Railway will construct with the Company forces a one-story frame and timber warehouse at Seattle, Wash., to cost approximately $25,000.

The Chicago, Rock Island & Pacific Railway has awarded a contract for the construction of a N. & W. type junior cinder handling plant at Goodland, Kans., to the Roberts & Schaefer Company, Chicago, Ill.

The Atlantic Coast Line Railroad has awarded a contract for the construction of shops at Chatmar, Fla. to cost approximately $60,000.

The Fairport Painesville & Eastern Railroad plans to erect shops and roundhouse at Fairport, Ohio.

The Missouri Pacific Railroad has awarded a contract for the construction of a 5-stall brick and concrete addition to the enginehouse at Nevada, Mo., to T. H. Jonson, Sedalia, Mo., to cost approximately $25,000.

The Chicago & Northwestern Railway is expending $65,000 on its shops at Antigo, Wisc.

The Yazoo & Mississippi Valley Railroad plans to expend about $160,000 on its shops and terminal at Cleveland, Miss.

The Atlantic Coast Line Railroad will build a roundhouse at Chatmar, Fla.

The New York, Chicago & St. Louis Railroad has awarded a contract for the construction of a one-story machine shop, at Frankfort, Ind. to cost approximately $75,000, to the Austin Company, Chicago, Ill.

The Missouri Pacific Railroad plans to make additional improvements to its reclamation plant at North Little Rock, Ark.

Items of Personal Interest

L. C. Shultz has been appointed master mechanic of the Southern Railway, with headquarters at Atlanta, Ga. **C. G. Goff** has been appointed master mechanic at Birmingham, Ala., and **H. C. Trexler** has been appointed master mechanic at Somerset, Ky.

M. R. Reed, has been appointed master mechanic on the Fort Wayne division of the Pennsylvania Railroad, with headquarters at Fort Wayne, Ind., succeeding **O. C. Wright**.

J. K. Morgan, general foreman of the locomotive department of the Chicago, Rock Island & Pacific Railway, with headquarters at Little Rock, Ark., has been appointed to master mechanic, with headquarters at Delhart, Ind.

J. K. Morgan, formerly general foreman, locomotive department of the Chicago, Rock Island & Pacific Railway, has been appointed master mechanic, with headquarters at Dalhart, Texas, succeeding **A. Hambleton**.

J. W. Womble, mechanical superintendent of the Midland Valley Railroad, with headquarters at Muskogee, Okla., has been appointed mechanical superintendent of the Kansas, Oklahoma & Gulf Railway.

T. E. Bliss, formerly assistant engineer of the St. Louis-San Francisco Railway, has been appointed division engineer, with headquarters at Ft. Worth, Texas, succeeding **G. W. Koontz**.

A. M. Lawhon has been appointed master mechanic of the Southern Railway, with headquarters at South Richmond, Va., succeeding **C. G. Goff**.

J. L. Rawlings has been appointed assistant road foreman of engines of the Seaboard Air Line Railway, with headquarters at Norlina, N. C.

George E. Goodship, assistant superintendent of the Detroit yards and the Toledo division of the Michigan Central Railroad, with headquarters at West Detroit, Mich., has been appointed superintendent, with the same headquarters.

G. C. Jones has been appointed general road foreman of engines of the Atlanta Coast Line Railroad, with headquarters at Jacksonville, Fla.

O. Small has been appointed master mechanic of the Southern Railway, with headquarters at Alexandria, Va., succeeding **A. M. Lawhon**.

W. H. Keller has been appointed master mechanic of the Lousiana & Northwest Railroad, with headquarters at Homer, La., succeeding **J. T. Simpson**, resigned.

R. D. Bulluck has been appointed master mechanic of the Atlantic Coast Line Railroad, with headquarters at Rocky Mount, N. C., succeeding **J. H. Painter**, who has been transferred to Wilmington, N. C.

W. R. Lye, formerly district superintendent of motive power on the New York Central Railroad, with headquarters at Elkhart, Ind., has been appointed similar position over the Third district, with headquarters at Collinwood, Ohio, succeeding **O. M. Foster**, retired.

H. M. Lull has been appointed assistant to the president of the Louisiana & Texas Lines of the Southern Pacific Company, with headquarters at Houston, Texas; **R. W. Barnes** has been appointed chief engineer, with headquarters at Houston, Texas, succeeding **H. M. Lull**, and **E. A. Craft** has been appointed engineer of maintenance of way, with headquarters at Houston, Texas.

George W. Curtiss has been appointed to superintendent of the Norfolk division of the Pennsylvania Railroad, with headquarters at Cape Charles, Va.

Myron Robbins, formerly road foreman of engines on the New York Chicago & St. Louis Railroad, with headquarters at Ft. Wayne, Ind., has been appointed to supervisor of locomotive and fuel, with headquarters at Cleveland, Ohio, succeeding **C. E. Trotter**, resigned.

L. B. Allen, formerly superintendent maintenance of way of the Chesapeake & Ohio Railway, has been appointed assistant to the vice-president, with headquarters at Richmond, succeeding **G. D. Brooke**, promoted.

F. F. McCarthy has been appointed district superintendent of motive power of the New York Central Railroad, with jurisdiction over the fourth district, with headquarters at Elkhart, Ind.

R. M. Stimmel, assistant chemist of the Chesapeake & Ohio Railway, with headquarters at Huntington, West Va., has been appointed to the position of chemist in charge of water treatment on the Hocking Valley Railway, with headquarters at Columbus, Ohio.

J. B. Briscoe, acting superintendent on the Panhandle division of the Atchison, Topeka & Santa Fe Railway, with headquarters at Wellington, Kan., has been appointed to superintendent with the same headquarters.

Benjamin Bell, Jr., has been made editor of the Chesapeake & Ohio Employees' Magazine, succeeding **A. B. Tunis**, resigned.

D. T. Daly has been appointed division engineer on the East Florida division of the Seaboard Air Line Railway, with headquarters at West Palm Beach, Fla., succeeding **H. O. Kaigler**.

C. B. Ranson has been appointed road foreman of engines in charge of the East Carolina division, with headquarters at Andrews, S. C., succeeding **C. A. Goodwin**, deceased.

R. L. Davis, acting valuation engineer of the St. Louis-San Francisco Railway, with headquarters at St. Louis, Mo., has been appointed valuation engineer with the same headquarters.

D. M. Driscoll, assistant superintendent on the Lake Superior division of the Northern Pacific Railway, with headquarters at Duluth, Minn., has been promoted to assistant to the general superintendent of the Eastern division, with headquarters at St. Paul, Minn.

R. E. Dougherty, engineering assistant to vice-president of the New York Central Railroad, with headquarters at New York, N. Y., has been appointed to engineering assistant to the president, with the same headquarters.

A. H. Webb, superintendent of the Wichita division of the Missouri Pacific Railroad, with headquarters at Wichita, Kan., has been appointed special assistant to the vice-president and general manager, with the same headquarters.

Supply Trade Notes

J. Dalrymple Rogers has resigned as London manager of the **Baldwin Locomotive Works**. **Ashton Dorr**, formerly assistant manager of the Paris office, succeeds Mr. Rogers as manager of the London office.

Vernon C. Ward has been appointed manager of sales of the steel construction department of the **Jones & Laughlin Steel Corporation**, with headquarters at Pittsburgh, Pa.; **G. H. Danforth** has been appointed contracting engineer of the Fabricating division.

Samuel H. Worrell has been appointed general manager of sales of the **Detroit Seamless Steel Tubes Company**.

E. F. O'Connor has been appointed representative on the southeastern territory for the **Edna Brass Manufacturing Company**, with headquarters at Richmond, Va.

G. G. Jones, manager of the Chicago office of the **American Locomotive Company**, has been appointed sales engineer.

The Chicago Tube & Iron Company and **Warren Corning & Company** have been consolidated under the name of the **Chicago Tube & Iron Company**. **E. E. Peter** remains chairman. The other officers of the company will be: **W. S. Corning**, president; **F. Gardener**, vice-president and general manager; **E. M. Peter**, treasurer, and **E. S. Nathans**, secretary.

Harry Donovan has resigned as general manager of the manufacturing department of the **General American Car Company**, and the position has been abolished.

John Parker has been appointed New England representative of the **Rolling Bearing Company, Inc.**, Syracuse, New York.

The following officers were elected at a recent meeting of the board of directors of **Pratt & Lambert, Inc.: J. N. Welter**, chairman of the board; **A. D. Graves**, president; **H. E. Webster**, senior vice-president; **J. P. Gowing**, vice-president; **W. P. Werheim**, treasurer, and **R. W. Lindsay**, assistant treasurer.

The O'Malley Beare Valve Corporation has opened a city sales office at 217 Railway Exchange building, Chicago, Ill.

Norman C. Naylor, who has been appointed district sales manager of both the **American Locomotive Company** and the **Railway Steel Spring Company**, with headquarters at the McCormick building, Chicago, Ill.

J. J. Gilmore has been appointed manager of sales of the Alabama district of the **American Steel & Wire Company.**

The Cleveland Punch & Shear Works Company, has removed its Philadelphia, office at 321 Bulletin building to 1201 Pennsylvania building, Philadelphia, Pa.

Gerald Firth, formerly works manager of the **Firth-Sterling Steel Company**, McKeesport, Pa., has been appointed general manager.

The Positive Lock Washer Company, Newark, New Jersey, has appointed the **Lundie Engineering Corporation** of New York and Chicago as its exclusive railroad sales agents for the United States and Canada.

Allen Sproull & Allen, Fort Worth, Texas, will in future represent the **Bridgeport Brass Company**, of Bridgeport, Conn., in the southwest.

Shirley S. French, vice-president and general manager of the **General Fireproofing Company**, Youngstown, Ohio, has been appointed president of the **Berger Manufacturing Company**, Canton, Ohio, division of the **Central Alloy Steel Corporation**, Massillon, Ohio.

M. A. Blessing, assistant manager of sales of the **Jones & Laughlin Steel Corporation**, with headquarters at Chicago, Ill., has been appointed district sales manager, with the same headquarters.

L. E. Porter, treasurer of **S. F. Bowser & Company**, has been elected vice-president in charge of industrial sales. **T. D. Kingsley**, vice-president in charge of commercial sales, and **D. C. Milligan** has been elected vice-president in charge of foreign sales.

R. C. Brower has been appointed general manager of the **Timken Roller Bearing Service Company**, Canton, Ohio.

Leon E. Haynes has been appointed assistant advertising manager of the **Buffalo Forge Company**, Buffalo, New York.

H. W. Dillon has been made Philadelphia sales manager of the **Chicago Pneumatic Tool Company.**

The Corrigan McKinney Steel Company is the new name of the firm formerly known as the **McKinney Steel Company**, Cleveland, Ohio.

W. H. Hans has been made Detroit manager of the **Whiting Corporation**, succeeding **R. E. Prussing**, promoted to the home office, at Harvey, Ill.

Harry J. Grossman has been appointed manager of the Cleveland office of **Sherman Service Engineer.** Mr. Grossman's promotion comes after twelve years' service in various capacities with the company.

Lauren J. Drake, formerly president of the **Galena Signal Oil Company**, has resigned to become president of the **Union Tank Car Company**, of Chicago, Ill.

W. H. Winterrowd, assistant to the president of the Lima Locomotive Works, Inc., has been elected a vice-president, with headquarters at New York City. Mr. Winterrowd was born on April 2, 1884, at Hope, Ind. He is a graduate of Purdue University, class of 1907. Mr. Winterrowd was employed as a blacksmith helper on the Lake Erie & Western Railroad at Lima, Ohio, and as a car and air brake repairman on the Pennsylvania Railroad, West, at Dennison, Ohio. He was a special apprentice on the Lake Shore & Michigan Southern and in 1908 entered the service of the Lake Erie, Alliance & Wheeling as enginehouse foreman, with headquarters at Alliance, Ohio. In 1909 he became night enginehouse foreman of the Lake Shore & Michigan Southern at Youngstown, Ohio, and in 1910 was promoted to roundhouse foreman at Cleveland, Ohio, he later became assistant to the mechanical engineer. In 1912 he was mechanical engineer of the Canadian Pacific Railway being later appointed assistant chief mechanical engineer, in which position he remained until 1923, when he was appointed assistant to the president of the Lima Locomotive Works.

Air Reduction Company, Inc., has acquired all the assets of the **Dayton Oxygen and Hydrogen Products Company** of Dayton, Ohio, thus adding another plant to the chain of fifty-two plants and one hundred and sixty-nine warehouses that guarantee prompt service to Airco customers throughout the United States. The Dayton plant will furnish a new production and distributing point for the Air Reduction Sales Company to serve customers in the southwestern section of Ohio with Airco oxygen and other gases used in welding and cutting.

Obituary

Fred M. Nellis, special representative of the Westinghouse Air Brake Company and secretary of the Air Brake Association, died suddenly in his office in New York on October 16. Mr. Nellis was born at Tionesta, Pa., February 27, 1862. He learned the machinist trade at Dennison, Ohio, and later became a locomotive fireman and engineer on the Panhandle division of the Pennsylvania Railroad. In 1882 he entered the service of the Westinghouse Air Brake Company as demonstrator on its instruction car. In 1895 Mr. Nellis began conducting the air brake department which was a feature of railway and locomotive engineering. At this period he had entered Cornell University, taking a special course in mechanical engineering and graduated with the class of 1899, when he resumed his association with the Westinghouse Air Brake Company, which he served in various positions of responsibility. He continued to conduct the air brake department of RAILWAY AND LOCOMOTIVE ENGINEERING, and in 1902 was elected vice-president of the Angus Sinclair Company, publishers of the paper and continued in this capacity until 1907. In 1910 he became New England representative of the Westinghouse Air Brake Company at Boston, Mass., and since 1915 has been special representative of the company at New York. As secretary of the Air Brake Association, Mr. Nellis was largely responsible for the success of that organization. He had served it as secretary for 25 years, when in 1924, in recognition of his work, he was elected secretary for life. Mr. Nellis had an unusually wide acquaintance in railroad circles, where his genial personality and kindly spirit brought him the honor and respect of all who knew him best.

Fred M. Nellis

George A. Harwood, vice-president of the New York Central Lines, with headquarters at New York, N. Y., died on November 4, of heart disease, in a hospital at White Plains, New York. Mr. Harwood was born on August 29, 1875, at Waltham, Mass., and was graduated from Tuft College with the degree of B. S. of civil and electrical engineering in 1898. He entered the railway service in 1893 in the engineering department of the Fitchburg Railroad and remained with that road until 1900 when he entered the service of the New York Central Railroad in the engineering department. He was appointed chief engineer of improvement in the electric zone 1906. He was in charge of the construction of Grand Central Terminal, with other improvements and developments in New York City, Buffalo, Cleveland and other places. He was appointed engineering assistant to the vice-president in 1916, and in 1918, engineering assistant to the federal manager of the New York Central Railroad. He was appointed chief engineer of all the road in July, 1917, and in 1920 became assistant to the president. In 1924 he was appointed vice-president in charge of improvements and developments, which position he was holding at the time of his death.

Dr. William Seward Webb, who was president of the Wagner Palace Car Company until its merger with the Pullman Company, died at his home near Burlington, Vt., on October 29. Mr. Webb was born January 31, 1851, at New York City, and a graduate of Columbia College. He entered railway service 1883 as president of the Wagner Palace Car Company, which position he held until January 1, 1900, when the company was absorbed by the Pullman Company. He was also president of the Adirondack & St. Lawrence Railway

during its construction and until the lease of the line to the New York Central Railroad, and was until 1905 president of Rutland Railroad and St. Lawrence & Adirondack Railroad.

John Skelton Williams, receiver of the Georgia & Florida Railroad, who was recently elected chairman of the board, died on November 4, at his home in Richmond, Va. Mr. Williams was born on July 6, 1865, in Powhattan County, Va., and a graduate of the University of Virginia. He entered railway service 1895 as president of Georgia & Alabama Railway, and in 1889 purchased with his associates a controlling interest in the roads which then comprised the old Seaboard Air Line System, of which he was elected president. He consummated the purchase of the Florida Central & Peninsular Railroad, of which he was elected president October 19, 1899. He conceived and developed the plan for the formation of the greater Seaboard Air Line System and was chairman of the board of directors. From 1907 until 1913 he was also president of the Georgia & Florida Railway. Mr. Willians was also director of the Division of Finance and Purchases, United States Railroad Administration. In July, 1921, he became receiver of the Georgia & Florida Railway, which position he held until the recent reorganization of the road.

New Publications

Books, Bulletins, Catalogues, Etc.

Westinghouse Gas-Electric Motor Coach:—A new gas-electric motor coach which was seen for the first time at the A. E. R. A. Convention in Cleveland, is that built by the International Harvester Company and completely electrically equipped by the Westinghouse Electric & Manufacturing Company. This coach, which has a seating capacity of 28, is equipped with a 40 kw. generator and two 27 hp. motors, an outstanding feature being the unit power plant. The motors are mounted in tandem, thereby permitting a standard type of rear axle with a single drive shaft. Other electrical equipment includes a directional and braking controller, a combined foot pedal and generator field switch, a generator field resister, braking resistors and wiring details. The Westinghouse Company has produced Folder 4729—The International Harvester Gas-Electric Motor Coach—covering this equipment and copies are available at any of the Westinghouse district offices or from the Transportation Section, Department of Publicity, East Pittsburgh.

Roller Bearing:—The Hyatt Roller Bearing Company has recently issued bulletin containing data of value to engineers and draftsmen concerning with the designing or development of plant and production equipment.

Aside from the conventional load and rating table it includes formulas for determining bearing sizes for specific applications, suggestions for mountings, with drawing and illustrations on diversified Hyattized equipment, and construction details of all types of Hyatt roller bearings.

Lead Base Babbitting:—Folder 4474, describing the babbitting of bearings and explaining the use of the Westinghouse Automatic Electric Babbitting Pots has just been released by the Westinghouse Electric and Manufacturing Company. It describes also the lead base babbitt, alloy No. 25, a product of the Westinghouse Company. This folder may be obtained from any of the district offices of the Westinghouse Company or from the Publicity Department at East Pittsburgh, Pa.

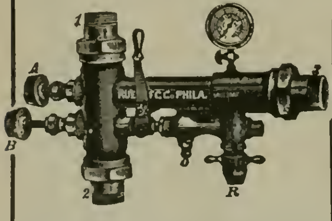
Steel Rolling Shutters and Doors:—The Cornell Iron Works, Inc., Long Island City, New York, have just issued a 32-page catalogue of their steel rolling shutters and doors. Various uses are described with full details of construction, dimensions and specifications. The catalogue is well illustrated with installation of these doors made by the company in railroad and other warehouses, factories and other structures. Copies of the catalogue may be obtained from the company.

Arc Welding of Structural Steel:—The Westinghouse Electric and Manufacturing Company have just issued a 31-page publication, S. P. 1767, The Arc Welding of Structural Steel that is very opportune, in view of the increased interest and activity in the arc-welding of steel building.

The first part of this publication deals with the arc welded buildings at the East Pittsburgh Works of the Westinghouse Company. The succeeding sections describe the erection methods, the test and inspection of arc welds, and the metallurgy of welding. The publication is completed with a discussion of the testing of actual joints and a very detailed description of the results of the tests conducted at the Carnegie Institute of Technology.

This special publication, which also includes a description of the single and multiple operator arc welding equipment, the gas engine driven and the portable belted generator equipment and the Westinghouse Auto Arc, may be obtained from any of the district officers of the Westinghouse Company or from the Publicity Department at East Pittsburgh, Pa.

Motorized Power:—The General Electric Company, Schenectady, New York, has issued a 12-page bulletin illustrating G-E motorized power which include electric locomotives, electric tractors and trucks, cranes and handling equipment. Copies of the bulletin may be obtained from any of the district offices of the company or from the Publicity Department at Schenectady, New York.



Railway and Locomotive Engineering

A Practical Journal of Motive Power, Rolling Stock and Appliances

Vol. XXXIX 136 Liberty Street, New York, December, 1926 No. 12

Detroit Toledo & Ironton Railroad New Gas-Electric Cars

The two new gas-electric cars which have been placed in regular service between Delary, Michigan, and Bainbridge, Ohio, are fulfilling expectations by maintaining the schedule of passenger train service. Although their service to date has been sufficient, there is no available comparative operating data as yet.

The cars cover the 280 miles between these cities in approximately nine and one-half hours. They are of all-steel and aluminum construction, built to the road specifications by the Pullman Company, in cooperation with the Westinghouse Electric & Manufacturing Company and the Hall-Scott Motor Company. The length over all is 72 feet 6 inches, height is 14 feet and the width 10 feet 4 inches. The weight of each car is approximately 66 tons. Each car comprises four compartments. At the front is an operator's compartment or cab which is 3 feet 6 inches in length. The operator is protected in front by shatter-proof glass. Just behind the operator's cab and connected to it by a door is the mail compartment, a little over 15 feet in length, this conforming to R. M. S. standards. This contained the full equipment of an up-to-date mail car. The sliding side doors are fitted with mail arms, safety visor, on either side. A small safety door under the racks leads to the baggage compartment, but under operating conditions this is kept locked from the mail compartment.

The baggage compartment, 13 feet 11½ inches in length, is in the center of the car. This has sliding doors on both sides.

A double-coil hot water heating plant is situated in one corner of the baggage compartment. Hard coal is used as fuel, this being kept in a steel box assuring cleanliness. A coupling at the side of the car adjacent to the heater is provided for connection to the steam line in yards of terminals.

From the baggage compartment a door leads into the smoking compartment adjoining, another door in turn leading into the passenger compartment at the rear.

The smoking compartment is 8 feet 10⅜ inches in length, containing three double seats on each side.

The passenger compartment at the rear of the car is

Gas-Electric Car in Service on the Detroit Toledo and Ironton

26 feet in length, containing 17 double seats. These are of steel frame construction, with stationary low-back twin seats, upholstered in gray mohair plush. Seats in the smoking compartment are of similar construction, upholstered in green Spanish leather.

In the passenger compartments, magnesite flooring, ⅜ inch thick, is provided. The baggage and mail compartments have double wooden floors, while that in the lavatories of the passenger and mail compartments is of rubber tiling.

At the rear of the coach is a vestibule, 2 feet 11⅜ inches in length. There is a door at each side and one at the end. Safety covers are provided for the steps at the sides.

The roof frame is of steel covered with steel sheathing ⅛ inch in thickness. The roof sheets of the upper and lower deck are of aluminum alloy 1/16 inch in thickness.

Inside finish is composed of aluminum throughout. The exterior is olive green with a varnished finish.

Side, end, and vestibule doors of the passenger compartment are of Mexican mahogany. Passenger compartment window sashes are also of mahogany. Standard sash fixtures and weatherstrips are included.

Two water coolers are installed in each car, one in the mail compartment and one in the passenger compartment. A washstand is installed in the passenger compartment.

Five ventilators are supplied in the main passenger compartment, two in the smoker, two in the baggage-room and two in the mail room.

All trimmings are finished in statuary bronze. All metal fittings are painted to conform to the general scheme of decoration.

Lighting fixtures are of aluminum, located on the lower deck sill about 6 feet apart.

The power units consist of two Hall-Scott gasoline motors under each car, with an approximate horsepower rating of 150 horsepower apiece. Engines in car No. 35 have a bore of 5 inches with a 7-inch stroke, while those in car No. 36 have a 5-inch bore with a 6-inch stroke. A maximum speed of 1800 r. p. m. is possible but is regulated by governors to about 1700 r. p. m. at present.

Motors are hung under each side of the car beneath its baggage compartments and can be easily reached through steel coverings in the floors. The rotation of the motors is opposed, one being clockwise, the other counter-clockwise, to reduce vibration. Each motor is direct-connected to the armature shaft of a 750-volt generator with an auxiliary generator for battery charging direct-connected to the armature shaft of the larger generators.

A force-feed oiling system is provided for the motors. This is equipped with filters and gauges to show oil pressure. The gasoline feed to dual carburetors is made through 12-volt electrically operated "Auto pulse" pumps, four for each engine, the amount of gasoline pumped to the carburetors depending on the operation of the throttle.

The engine starter is of 32-volt capacity, operated through a solenoid switch controlled from the cab.

The ignition is of dual type, automatic-spark advance, 12-volt system using two distributors and a double set of spark plugs. The engine is water cooled, circulation being by pump and controlled by thermostats at the connections from the engine to the radiators.

The radiator is air cooled through the assistance of a fan placed close behind the radiator core and direct-connected to the front end of the crankshaft. The radiator is suspended on cushions to the underframe. The fan is shrouded. The core is protected by means of a screen guard. Motor meters are connected to the intake manifold water jackets to show the temperature of the water in the cooling system.

Exhaust from the engines is carried up through the baggage room by 3-inch pipe, the muffler being mounted on the roof of the car.

Built into the engine and driven directly from the pump shaft is a specially designed water-cooled air pump. This is equipped with air strainer and fittings to take care of the air supply required for the air brake, and is furnished with a governor that opens a by-pass valve when the pressure reaches 90 pounds and closes it when the pressure falls below 85 pounds.

Generators are shunt-wound with a separately excited field for rapid "pick-up." A small amount of the 32-volt current is used for the excitation of the fields. Generators have a voltage of 750 volts d. c. at 1700 r. p. m. and 600 volts at 1400 r. p. m., the latter being the nominal running speed. The generator is cooled by air which is drawn through the armature with the assistance of a blower mounted to the rear of the motor flywheel and expelled through holes in the flywheel housing.

An inter-connection makes possible the operation of both truck motors together or separately from either generating unit. This is of advantage in case of the breakdown of either generating unit, in which event the remaining unit supplies the tractive effort to four wheels instead of two. During the test of the cars, the regular schedule was maintained for 60 miles with but one motor running.

There are two box frame D. C. railway motors, each supplying power to one axle of the front trucks. They are geared to the axles through helical forged gears with a ratio of 18 to 59 for 36-inch wheels.

Two 32-volt batteries supply the power for the starting motors and lighting circuit. The lighting current is split between the two battery units. All wires are encased in aluminum conduit. No train wires are installed. A 12-volt battery supplies the current for the ignition system. Batteries are recharged by means of the auxiliary generators.

All power switches are of the pneumatic type and are remotely controlled from the driving cab through the master controller.

The control of the speed of the engines is effected by means of a special control valve in the cab which by regulating the pressure on a diaphragm at each engine operates the throttle, the engines being governed to 1700 r. p. m. The speed of the traction motors is controlled by varying the voltage of the generators, either by strengthening the generator fields or increasing the engine speed.

The increased field strength is obtained by cutting resistance out of the field circuits, both generator fields being controlled by the master controller.

An increase of engine speed is obtained by opening the throttle valve; both throttles being controlled by the one valve and so adjusted that the speed of both engines is approximately the same at all positions of the throttle valve. The proper use of these methods of controlling the generator voltage will give very smooth and rapid acceleration and a flexible control at all car speeds.

The operation of the several solenoid switches for starting and reversing is controlled from the cab through the 32-volt system.

The entire power units are of the "underslung" type. The generators are bolted to a special support with Spanish felt to eliminate vibration, and the front end of the engines is attached by a hinged arrangement to allow for expansion, using a rubber cushion to deaden the vibration.

Operator's window is fitted with a heavy electrically driven windshield wiper. An instrument panel below the window contains the majority of the control buttons, gauges, ammeters, etc. A single throttle controls the speed of both engines.

A fuel capacity of 366 gallons is contained in the two fuel tanks hung beneath the car. Benzol developed as a by-product by the Ford Motor Company is used as fuel.

Brakes are Westinghouse straight-air type having emergency features, single end controlled. An air horn is operated from the cab.

The trucks are of cast steel. Thirty-six-inch rolled-steel wheels are mounted on 5-inch open-hearth steel axles 9 feet in length. Journal boxes, bearings and wedges are ARA standard.

Each motor car, weighing about 66 tons, will balance at approximately 49 miles an hour on one-per-cent grade at 1400 r. p. m. A maximum speed of 60 miles an hour is possible.

Crew consists of motorman, flagman, and conductor, who were taken from the displaced passenger trains.

International Transport Information Center

A third general European conference on communications and transit will be held next year, according to an announcement in a report issued by the League of Nations on communication and transit. One of the important subjects to be considered is the establishment of a center for the co-ordination of information in regard to transport and for the exchange of statistics in relation thereto.

2-8-4 Type Locomotive for the Illinois Central

A Design Similar to the A-1 Which Was Tested on the Boston & Albany

The Lima Locomotive Works, Inc., recently delivered to the Illinois Central fifty locomotives of the 2-8-4 wheel arrangement for use in freight service. These are similar to the A-1 design which was given extensive tests on the Boston & Albany, a detailed description of which was published in the May, 1925, issue of Railway and Locomotive Engineering. A summary of the tests of the A-1 was published in the December, 1925, issue.

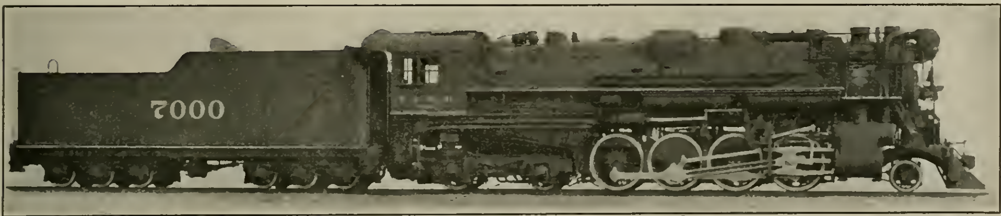
The new engines of the Illinois Central develop a tractive force of 69,400 lb., at 60 per cent cut-off and 81,400 lb. with the booster. The diameter of the driving wheels is 63 in., the boiler pressure 240 lb. per sq. in., and the diameter and stroke of the cylinders is 28 in. by 30 in., respectively. These figures are the same as those for the A-1 with the exception that the A-1 develops a tractive force with the booster of 82,600 lb. The new locomotives employ the limited maximum cut-off which of course, requires an increase in boiler pressure to offset the reduction in the ratio of mean effective pressure to initial pressure resulting from the limited cut-off.

A comparison of the new Illinois Central 2-8-4 locomotives with the A-1 is shown in the table of dimensions, weights and proportions. The Illinois Central locomotives have 500 lb. less weight on the engine truck, but the weight on the trailing truck has been increased by 3,700 lb. The total weight of the new locomotives is 388,000 lb., 3,000 lb. heavier than the A-1. The tender of the A-1 has a total weight of 275,000 lb. as compared with 286,000 lb. for the Illinois Central, but the fuel capacity of the latter is two tons greater. The boiler design of both the A-1 and the Illinois Central locomotives is essentially the same; neither are provided with combustion chambers, and the latter has 88 2¼-in. tubes as compared with 90 for the former. There is comparatively little difference in the amount of heating surface, as shown in the table, and it will be noted that the factor of adhesion is practically the same.

Forty of the Illinois Central locomotives are equipped with Elesco feedwater heaters and ten are equipped with Worthington feedwater heaters. The boiler is of the extended wagon top type and is provided with Nicholson thermic syphons, type E superheater and Nathan injectors. The firebox has a length of 150⅛ in. and a width of 96¼ in. with a grate area of 100 sq. ft. The grate bars are of cast steel. All 50 of the locomotives have du Pont Simplex type B stokers, the stoker engine being carried on the tender. Aside from the size of the firebox, the boiler does not differ materially from the usual type of design. Steam is taken from the dome through an outside dry pipe to the superheater header at the rear of the smokebox. The throttle is a Chambers front end type located in the smokebox just ahead of the smoke stack, as in the A-1. Branch pipe connections are provided on either side of the throttle casing from which the branch pipes lead down inside the front end, passing outside at points just above the cylinders.

The cylinders are cast steel, and the cylinder and valve chambers bushings are of Hunt-Spiller gun iron. Connection is made from the valve chambers to the saddle exhaust passage by means of cast pipes which are bolted to openings in the valve chamber extension heads at one end and against the face of the saddle casting at the other. The locomotives are equipped with a Franklin precision reverse power gear, steam distribution being effected by a Baker long-travel valve gear.

The locomotives have articulated main rods of normalized chrome vanadium steel the piston rods also being made of the same material. The driving box brasses are of phosphor bronze, chill molded, and are lubricated by means of Elvin lubricators. The ash pan is carried on the trailer truck frame. The trailer is of the four-wheel articulated type and the frame is a one-piece steel casting. The engine truck is of the Commonwealth design, equipped with Woodard constant resistance rockers. Both the engine and trailing truck journals are 6½ by 12 inches, with the exception of the rear trailing truck journals, which are 9 by 14 inches. This axle is driven by the booster.



2-8-4 Type Locomotive on the Illinois Central—Built by Lima Locomotive Works

The air brake and compressor equipment was furnished by the New York Air Brake Company, schedule LT. The compressors are mounted on the frame ahead of the cylinders, as shown. The headlight equipment is of the Pyle National Manufacture. In addition to the special equipment already mentioned, the locomotives are equipped with Moody driving box saddles, Parsons air-operated whistle rigging and combined steam chest and back pressure gages.

In arranging the control valves and equipment located in the cab considerable attention has been given to providing for the convenience and comfort of the engine crew. As far as possible all gages have been brought together in one location where the enginemen can see them at a glance. The various valve handles have been grouped and labeled with those most frequently operated and placed where they are most readily accessible.

The tender has a water capacity of 15,000 gal. and a coal capacity of 20 ton. It is equipped with six-wheel Commonwealth cast steel trucks which have boxes for 6 to 11 inches journals. The trucks are provided with clasp brakes. The loaded weight of the tender in working order is 286,000 lb.

Comparative Table of Dimensions, Weights and Proportions of the Illinois Central 2-8-4 Locomotive No. 7000 and of the Lima A-1

	7000	A-1
Railroad	Illinois Central	....
Builder	Lima	Lima
Type of locomotive	2-8-4	2-8-4
Service	Freight	Freight
Cylinders, diameter and stroke	28 in. by 30 in.	28 in. by 30 in.
Valves, gear, type	Baker	Baker
Valves, piston type, size	14 in.	14 in.
Maximum travel	8⅜ in.	8¼ in.
Outside lap	2 1/16 in.	2 1/16 in.
Exhaust clearance	1/16 in.	1/16 in.
Lead in full gear	¼ in.	¼ in.
Cut-off in full gear, per cent	60	60
Weights in working order:		
On drivers	248,000 lb.	248,200 lb.
On front truck	35,000 lb.	35,500 lb
On trailing truck	105,000 lb.	101,300 lb.
Total engine	388,000 lb.	385,000 lb.
Tender	286,000 lb.	275,000 lb
Wheel bases:		
Driving	16 ft. 6 in.	16 ft. 6 in.
Total engine	41 ft. 8 in.	41 ft. 8 in.
Total engine and tender	82 ft. 5¾ in.	82 ft. 6 in.
Wheels, diameter outside tires:		
Driving	63 in.	63 in.
Front truck	33 in.	33 in.
Trailing truck, front	36 in.	36 in.
Trailing truck, back	45 in.	45 in.
Journals, diameter and length:		
Driving, main	12 in. by 14 in.	12 in. by 14 in.
Driving, others	11 in. by 13 in.	11 in. by 13 in.
Front truck	6½ in. by 12 in.	6½ in. by 12 in.
Trailing truck, front	6½ in. by 12 in.	6½ in. by 12 in.
Trailing truck, back	9 in. by 14 in.	9 in. by 14 in.
Boiler:		
Type	Extended wagon top	Extended wagon top
Steam pressure	240 lb.	240 lb.
Fuel, kind	Soft coal	Soft coal
Diameter, first ring, outside	88 in.	88 in.
Firebox, length and width	150⅛ in. by 96¼ in.	150⅛ in. by 96¼ in.
Combustion chamber, length	None	None
Tubes, number and diameter	88—2¼ in.	90—2¼ in.
Flues, number and diameter	204—3½ in.	204—3½ in.
Length over tube sheets	20 ft.	20 ft.
Grate area	100 sq. ft.	100 sq. ft.
Heating Surfaces:		
Firebox and arch tubes	414 sq. ft	337 sq. ft.
Tubes and flues	4,750 sq. ft.	4,773 sq. ft.
Total evaporative	5,164 sq. ft.	5,110 sq. ft.
Superheating	2,111 sq. ft.	2,111 sq. ft.
Comb. evaporative and superheating	7,275 sq. ft.	7,221 sq. ft.
Tender:		
Style	Rectangular	Rectangular
Water capacity	15,000 gal.	15,000 gal.
Fuel capacity	20 ton	18 ton
General data, estimated:		
Rated tractive force	69,400 lb.	69,400 lb.
Rated tractive force, with booster	81,400 lb.	82,600 lb.
Cylinder horsepower (Cole)	3,400 lb.	3,400 lb.
Maximum curve		19 deg.
Weight proportions:		
Weight on drivers ÷ total weight engine, per cent	63.9	64.2
Weight on drivers ÷ tractive force	3.57	3.58
Total weight engine ÷ comb. heat. surface	53.3	53 3
Boiler proportions:		
Tractive force ÷ comb. heat. surface	9.54	9.61
Tractive force × diam. drivers ÷ comb. heat. surface	601	605
Firebox heat. surface ÷ grate area	4.14	3.37
Firebox heat surface, per cent of evap. heat. surface	8.02	6.60
Superheat. surface, per cent of evap. heat. surface	40.8	41.4
Comb. heat. surface ÷ grate area	72.75	72.2

L. F. Loree on Steam Transportation

The steam locomotive, and not electricity, will continue to be the dominant factor in the development of modern railroad transportation, it was asserted by L. F. Loree, President, the Delaware & Hudson Company, at the fall meeting of the Holland Society of New York.

"The substitution of electric haulage for steam railway transportation is widely urged," said Mr. Loree. "While this contest may be expected to continue long in the future, perhaps usurping and stabilizing itself in restricted fields, the dominance in its larger aspect will depend largely upon the ability, genius, courage and tenacity of the exponents of one or the other method of transportation For myself, I have an abiding faith that for the main purpose of the railroad—the transportation over long distances of heavy articles—the unit system of transportation (steam locomotive) will be the dominant one."

By way of contrasting the swift growth of transportation, through mechanical developments, Mr. Loree showed that under the first method undertaken by man, that of packing his own burden, there could be transported yearly 162 ton miles, at a maximum. A horse could haul 780 ton miles a year, it was stated. Mr. Loree found that even as late as 1750 almost the whole land-carriage of Scotland, and of several parts of England, was conveyed on the backs of pack-horses.

In their freight car service last year, the railroads transported 452,827,593,844 net tons one mile with the aid of 1,415,000 employees, Mr. Loree explained. Comparing the extremes only he pointed out that 152 ton miles per year was the paying-load carrying capacity of the porter, whereas the railroads transported during the year, 320,019 ton-miles per individual freight employee.

Such a performance would have been impossible without the modern steam locomotive, which Mr. Loree agrees is "the heart and soul of transportation." After describing its development in detail, from the first small engine to the high-powered locomotives of today, Mr. Loree points out that it is, nevertheless, only a part of a huge assemblage.

"The vehicles in which freight and passengers are carried have undergone an analogous development. We began to move freight in the chaldron, with a carrying capacity of something over two and one-half tons; by 1860 we had developed a five-ton car, with four wheels, the axles fixed in the frame. The Civil War compelled an increase in the carrying capacity and we advanced to ten tons; with the wonderful increase in railroad mileage in the early 1870's the capacity was increased to fifteen tons; in 1876 the twenty-ton car was introduced; in 1883 the twenty-five ton; in 1885 the thirty-ton; in 1895 the forty-ton; in 1900 the fifty-ton; and in 1915 the seventy-ton, of which we now have in use more than 121,000. Meanwhile the paying load has increased more than 50 per cent with reference to the weight of the vehicle.

"Quite as characteristic has been the development of the working force. In the railroad service, the men, besides the physical requirements, are held to a high state of discipline. In the main, they are subject to be called upon for duty at all hours of the day and upon all days of the year. They are under control, not only as to the disposition of their time, but as to some of their personal habits. They are engaged in a hazardous occupation.

"The effect of discipline and drill is to mold, to make the whole mass, as it were, an instrument, which, at the will of one, may exert its force in a certain direction and to a certain end.

"As to the management, it is character and power of will that enables one, as a leader, to control masses of men. He must subject all alike, himself included, to that discipline which is a bond stronger than iron; more impervious than adamant. He must have not only courage and endurance, but also that indefatigable quality called "pluck," and, as well, instinct, that incomprehensible something which takes the bird to its nest in the vast sameness of the prairie, or the bee to its home in the hollow tree hidden in the labyrinth of the forest.

"The railroad rests its hope of successful operation very largely upon organization, discipline, and continuity of employment. It must have a continuous policy, a history personal in its character, and an *esprit de corps* founded on mutual experience, respect and confidence. Here, as in other fields, the whole is not merely the sum of all the parts, but the sum plus the interaction of the parts, regulating, inhibiting, stimulating, multiplying their effectiveness and force."

Balancing Factors in the Use of Freight-Train Cars*

By L. K. Sillcox

General Superintendent of Motive Power, Chicago, Milwaukee and St. Paul Railway

It has been said that the function of transportation is to overcome the economic handicap of distance. Because we have created in this country the most extensive system of railroads and have the most efficient transportation at the lowest cost, we have been able to develop and utilize our natural resources and man-power to better advantage than any other country of the world. We have within our boundaries about two-fifths of the railroad plants in the world and about four-fifths of all the world's motor cars. From the viewpoint of a miller, the distance from Montana wheat fields to Minneapolis is not measured in miles but in the *cost* of getting a ton of grain from the point of origin to the unloading track at the mill, on the one hand, and from the mill to the consumer of the finished product on the other hand; and the efficiency of our railroad transportation has consequently enabled the milling industries to avail themselves of the advantages which such centers as Minneapolis present with repect to labor supply and the location of markets. It has also made possible the economies of centralized manufacturing. As the growth of our national needs for transportation seems to be unlimited, the situation becomes more complicated, and also more worthy of our best effort.

Limitation of Railroad Capacity Because of Terminals

A railroad as a transportation machine is limited in its capacity by the ability of its terminals and its connections to handle and promptly dispose of its traffic. The provision of sufficient railway capacity at all times to meet maximum prospective demands of traffic appears, from the standpoint of the public interest and good transportation management, to be a sound policy, even though fixed charges, and to some extent expenses for mainitaining equipment and other facilities, are increased through employing such a policy, because it represents substantial surplus capacity most of the time and some reserve at all times. It should be kept in mind also that nothing is gained by having greater facilities for classification and transportation than to provide freedom of continuous uninterrupted movement and facilitate the interchange and delivery of business. It is lack of suitable and adequate terminal facilities generally, and the permitting of cars that should be held out to block yards and delay normal delivery, that causes equipment to stand still more than it should in order to cover a satisfactory number of miles per car per day in the direction of its required movement. In our efforts to expedite movement and to reduce cost, we have increased the size and weight of locomotives and cars very considerably. Even under the present circumstances the possible axle load on the existing standard gage probably will not exceeds 80,000 lb., while on some of the trackage of the country, especially in terminals, the permissible load per axle now hardly exceeds more than 53,000 lb., and, at present, the heaviest A.R.A. standard journal provides a maximum load per axle of only approximately 63,000 lb.

Terminal Expense

It is generally agreed that the problem of terminal expense is one of the most vital questions before the railroads today because more money is lost in terminal operation than in any other single branch of the service. While some may be considering the increase of track capacity to meet the very evident demand for quicker handling of less-than-carload freight, this can only result, in most cases, in increasing the storage capacity available through the use of freight cars. Some of the largest railroads have recently been experimenting with the use of motor trucks in the handling of short-haul less-than-carload freight. Other roads are using interchangeable shipping containers which are handled on flat cars in regular train movement.

Capital costs begin in any industry when labor-saving tools take the place of actual labor, and the proportion which they represent of the aggregate of all costs depends upon the extent of the use of labor-saving devices. When a machine, operated by one man, is introduced to displace ten men whose work it is able to do, the cost of its service is not in the wages of the operative alone, but in that sum plus the maintenance of the machine in conjunction with the fixed charges covering interest upon capital invested, depreciation, taxes, insurance, etc. If, subsequently, this machine is replaced by another costing twice the amount paid for the original, but capable of doing three times as much work, the new cost may be determined according to the same formula. Such changes as these are not made unless there is reason to believe that they will reduce the aggregate cost, and no thoughtful executive claims for one moment that the whole saving in labor is the net reduction in cost.

Reduction in grades, elimination of curvature, the introduction of heavier rails, the use of larger freight train cars and more powerful or more economical locomotives have all required vast outlay of capital. These expenditures have been incurred because there was ample reason to believe that they would add to the earning power of the properties in behalf of which they were made, but no executive ever intimated that they would not add to capital costs. On the other hand, however, it is believed that they would reduce operating expenses by a larger sum than that which they would add to interest and other necessary fixed charges. That they have somewhat reduced the proportion of operating costs to aggregate revenue is a matter of general record; but the definite relation of the savings in this direction to the actual addition to fixed charges is still a problem. That every substantial improvement in railway facilities ought to reduce the ratio of operating expenses and to a somewhat small degree increase the fixed charges is perfectly clear. It is equally evident that changes which have this effect should be encouraged in every possible way. Capital is the great labor-saving device and the means of all labor-saving additions. It is desirable that it should be utilized to the utmost practicable extent, especially where this is possible currently out of earnings at a rate such as to retire a reasonable amount of the capital annually and still carry the fixed charges in addition to the current operating expenses involved.

Problem of Slow Movement

One of the leading tasks confronting the traffic and operating departments today is the scarcity of cars and their low average daily movement. Statistics show that a freight car travels about 30 miles in 24 hours. It is known, from actual experience, that loaded freight cars are moved, while they are in transit, with very few ex-

*Abstract of a paper read before Railway Division of the American Society of Mechanical Engineers.

ceptions, at a speed of not less than 20 miles per hour and, quite often, at 40 miles per hour. If a car runs over 20 miles of track in an hour, it will cover 30 miles in one hour and thirty minutes. We then must ask ourselves what the car is doing the other 22 hours and 30 minutes of the 24 hours. It is evidently standing still, or being switched, or running empty, and a portion of each of the above items is unavoidable. We sometimes hear the statement that no means of improvement are known, under present conditions, and a suggestion that more unloading tracks at terminals be provided. We also hear demands for more cars and engines. When all is said and done we need to emphasize the fact that the best of systematic work on the part of the seven most important subordinate officials must be obtained, for without the intelligent and earnest co-operation of these officials the work of the most exacting and energetic executive is sure to fail. They are the roundhouse foreman, the car foreman, the chief dispatcher, the trainmaster, the traveling engineer, the yardmaster and the freight-house foreman. To bring this about, we need to have the most intelligent and best inspection, lubrication and light repair work on locomotives and cars before each trip, and the latter should contemplate a maximum uninterrupted mileage. A breakdown of one engine or one car will delay the whole train and a large number of disastrous derailments can be traced to careless or indifferent work on the part of the inspectors. Careful work by inspectors will also diminish terminal delays and the attendant lost motion. All employees connected in any way with the movement of a train should perform their duties strictly on schedule time, that is, engines should be put through the house for return trip as quickly as possible, ways to eliminate extraordinary delays between terminals should be discovered, and delays to trains or road engines by switch engines should be avoided. Successful car movement can only be accomplished by careful, painstaking work by those who are out in the field of action and in positions enabling them to watch and note every move that is made. This kind of supervision cannot be accomplished over long-distance telephone or by telegraph. The local officers need to detect the apparently insignificant things which impair the efficiency of the system, because railroad employees, as a class, while doing the great bulk of their work conscientously and well, are prone to slight the little things unless closely watched by their superiors. These co-called trivial things or circumstances, too numerous to list, are known to the practical man by intuition and actual acquaintance. If taken advantage of, they mean much in the proper dispatchment of cars and locomotives with a view toward maximum utilization and a proper minimum necessary investment for facilities and equipment to handle a given unit of business.

TABLE 1

District	Products of agriculture			Animals and products			Products of mines			Products of forests			Manufactures and miscellaneous			Grand total, all carload traffic		
	1925	1924	1923	1925	1924	1923	1925	1924	1923	1925	1924	1923	1925	1924	1923	1925	1924	1923
Eastern......	22.0	21.8	21.9	12.8	12.8	12.7	48.9	48.6	48.0	24.2	24.5	23.8	24.2	24.1	23.9	32.7	33.2	33.3
Allegheny....	22.0	21.2	21.4	13.4	13.5	13.3	52.8	52.0	51.0	25.9	25.8	26.2	28.4	28.3	28.8	38.6	38.5	39.3
Pocahontas...	16.6	16.5	17.7	12.0	11.6	11.8	57.4	57.4	56.7	27.3	27.3	27.6	26.1	26.5	27.6	51.8	50.7	49.5
Southern.....	16.4	16.5	16.9	11.7	11.8	11.6	48.1	47.6	47.0	25.4	25.5	26.1	24.4	24.1	24.1	31.5	31.1	31.5
Northwestern.	30.9	31.6	30.9	11.3	11.2	11.3	50.5	49.2	32.4	32.4	32.5	32.3	27.7	27.2	27.5	35.2	34.2	35.3
Central West.	25.7	27.6	26.6	11.5	11.5	11.4	46.9	46.7	46.4	30.1	30.2	30.7	26.7	26.7	26.1	30.7	30.7	30.5
Southwestern	20.8	22.1	21.8	11.8	11.5	11.7	43.2	43.3	43.0	26.2	26.4	27.3	26.4	26.3	26.7	28.3	28.4	28.4
Total all Districts......	23.4	24.4	24.1	11.8	11.7	11.7	50.3	49.7	49.1	28.0	28.1	28.4	26.1	26.0	26.0	34.4	34.1	34.5

Intensive Use of Cars

No greater responsibility confronts the administrations of the various railroads than that of attining greter utilization of equipment, materials, manpower and facilities. When considering the latter, it can be quickly appreciated that this feature not only involves more mileage and more tonnage with fewer units of equipment, but also takes into account the problem of advance in design to attain greater service. It may be assumed that design and utilization are relative in that the production of satisfactory construction must naturally keep pace in the development of the use of facilities. In order that these features may be advanced in proper relation to each other, there should be a thorough knowledge of the rate at which obsolescence accrues or exists in any given property, knowing that it will generally require a term of years in order to satisfactorily dispose of practices and establishments which may have been in force for some time.

Full utilization of freight train cars is not entirely a question of mechanical administration; it depends very much upon other factors, such as road, yard, shop and terminal facilities, as well as prompt handling of empty cars, to say nothing of the necessity for uninterrupted road movement of trains through the provision of passing tracks sufficiently long to meet modern tonnage requirements, to have trains properly blocked so that they may run between two terminals of maximum distance apart without interruption, to provide road and grade conditions of such a character that freight-train movement at a proper rate of speed, without disturbance, can be carried on for a maximum economical distance, efficiency of train loading, dispatchment, etc. In general, freight train cars are capable of performing more hours of service and attaining greater mileage per day than are now accomplished. Every carrier is confronted with the serious problem of proper design and spacing of engine and car terminals in relation to obtaining maximum utilization per day for all classes of equipment, with consequent speeding up of average train movement. By utilization is meant the miles run per car per day, the days serviceable per year, and the tons hauled per day. If new and overhauled cars are not of modern design, the object to be attained is not accomplished in the full sense of the word. In order to arrive at a maximum utilization with an economical maintenance cost, the officers in charge should have full knowledge of performance of such equipment, especially should obsolete freight car maintenance, shop and terminal facilities be studied and corrected if possible.

During 1925 the Car Service Division of the American Railway Association completed a study of the average loading of freight cars with various commodities carried by Class I roailroads in the United States, with a comparison for 1923 and 1924. The information indicates what use is being made of the freight cars and provides a means of determining to what extent the carrying capacity is employed by the various lines of industry and by the shipping public in the various districts of the country. The average of all cars loaded is influenced very greatly by the character of traffic, which changes not only from year to year, but also during different seasons, so that to attempt a study of the utilization of freight cars, a number of factors must be considered, requiring careful study

of the detailed data. The average freight car load for 1925 was 27.0 tons, the same as in 1924, compared with 27.9 tons in 1923 and the high average of 29.3 tons in 1920. Table 1 gives the number of tons in cars for carload freight originated (not including less-than-carload merchandise).

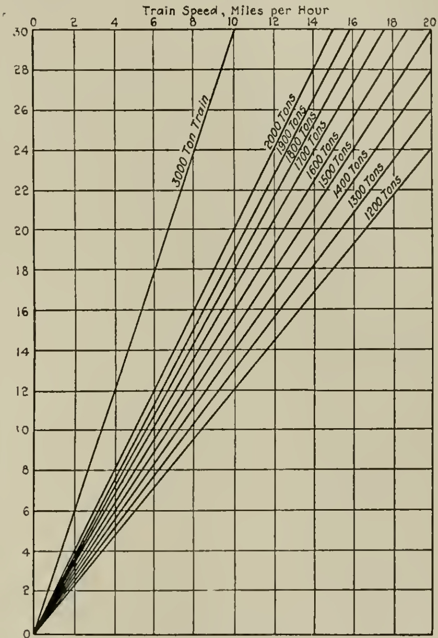
A detailed study of this information will show wide differences in the car loading as between railroads serving the same territory and covering specific commodities. For example, the loading of wheat in the section west of Chicago is 35 tons to the car on some roads, while others are obtaining as high as 44.9 tons, a difference of 9.9 tons to the car, or 28 per cent, accounted for almost entirely from a difference in car carrying capacity. For lines serving the eastern section of the country out of Chicago, the average loading fluctuates from 35.4 tons to 46.4 tons or 31 per cent. Conditions of like nature can be observed with regard to practically every other commodity. Therefore, a study of the statement prepared by the A.R.A. Car Service Division and an investigation by all railroads of the conditions on their line, should, through obtaining full co-operation on the part of the shippers, encourage greater use of the individual freight car as well as suggest the most economical carrying capacity for freight cars and eliminate any possible wastefulness in practice, thereby resulting in considerable benefit in the direction of economical and efficient service. It should be remembered, on the other hand, that a comparison of the total tonnage per car for one year compared with another means nothing unless all factors are taken into consideration. As a matter of fact, the present year may show the heaviest tonnage per car of any year up to date, and if so, will undoubtedly be brought about largely by the great increase in the production of mines, including sand, stone and gravel.

The performance of cars, locomotives and trains is a matter of sufficient importance to justify much study. Train runs are on a more or less arbitrary and specific basis, but car runs intermingle. Cars are picked up enroute between terminals, handled at terminals, set off between terminals, etc. The handling of cars may be divided into two groups, that is, on the road and in terminals. Handling on the road shows that the average speed of freight trains was 11.8 miles per hour in 1925 and the average mileage per car per day was 28.3. If all cars could be handled from terminal to terminal without interruption at 20 miles per hour, in 8-hour runs this would mean 160 miles per day. The train speed of 11.8 miles per hour expresses delays enroute for intermediate switching, meeting trains, held by signals, etc. It would seem that much attention should be given to roadway dispatching and facilities to increase train speed by eliminating movement interruptions, because the investment involved would not be in proportion to the investment necessary in equipment if train tonnage were to be further increased. For every mile per hour increase in train speed (terminal to terminal time), the gross ton-miles per train-hour factor is increased by the train tonnage. A 1200-ton train at 8 miles per hour will produce 9600 gross ton miles per train hour; at 9 miles per hour this will increase the gross ton miles per train hour to 10,800.

Therefore, when train tonnage cannot be controlled definitely because of fluctuation in traffic valume, it still remains within the control of a railroad to increase train speed, as every factor of speed increase is an equivalent of increase in gross ton miles per train hour. The lowest speed recorded for all Class I railroads in 1925 was 10.6 miles per hour, and the highest 15.9 miles per hour, or a difference of 50 per cent. This is a wide range and doubtless the lower figures can be improved with no increase in the cost. Train speed should not be construed to mean actual running speed, but the average rate at which the mileage is produced from initial to final terminal. It is improved by eliminating elements which delay train movements so that the hours consumed from initial to final terminal may be reduced. The elements which retard train movements are:

(a) Too great a frequency of tonnage revision due to improper assignment of power.

(b) Unbalanced regulation to tonnage movement in through and way freight trains, which should be corrected to eliminate, as far as possible, delays due to setouts and pick-ups, road switching, etc.



Resultant Gross Ton Miles Per Train Hour with Train Miles Per Hour and Gross Tons Per Train as Factors

(c) Dispatching of trains to eliminate delays for train meets, standby losses of time on sidings, etc.

(d) Siding and passing track arrangements to prevent complete stops.

(e) Spacing of trains, etc.

Unfortunately, there are no specific data to show terminal movement, but it may be considered as a retarding factor under present operation. It is essential that yard lay-outs be improved so as to permit cars to be worked through more rapidly. In order to overcome the present retarding factors, longer locomotive and train runs have been instituted with the hope of eliminating terminal delays as far as possible. This is a move in the right direction, but should be further improved by proper terminal facilities, in conjunction with appropriate placement of sanding, coaling and watering stations and suitable volume and quality of water supply where required.

Improvements have been made in locomotive performance. Fuel consumption per thousand gross ton miles has been reduced from 197 pounds in 1920 to 159 pounds in 1925 or 18 per cent. Trains have been more carefully handled because of better maintenance of air

brake equipment and education of trainmen, so that payments made for loss and damage to freight decreased 69 per cent in the same period; this being assisted somewhat by a better condition of freight cars. Gross ton miles per train-hour have improved likewise by reason of a slight increase in train speed and a marked increase in train tonnage, the latter being brought about by better train assembling and the use of larger power units. Car shortages have disappeared for sometime because of better distribution and movement. Empty car mileage, on account of characteristics of traffic, has remained about the same. The physical condition of freight cars and locomotives has improved as a result of better maintenance and at the same time the cost per unit of such work has been reduced.

While freight car miles per day have increased from 25.1 in 1920 to 28.3 in 1925, yet this has not been an expression of ultimate utilization, because the character of maintenance accorded has aided in the matter of availability. Freight car maintenance may be divided into two groups, one pertaining to heavy repairs and the other to light or running repairs. Heavy repairs become due in periods of about once every 8 or 10 years, whereas running repairs and inspection are a continuous necessity. While terminal handling may be considered the greatest retarding factor of freight-car movement, repairs may be considered as a somewhat important element. The bad order car situation has improved materially in the last few years and this applies to cars held out of service for heavy repairs. Cars requiring running repairs are usually not held more than a few days. The following table shows a comparison, on 100,000 individual units which were specially tabulated for a wide range of territory, of the car parts causing delays for repairs other than periodical overhauling, and which must be taken out of service and placed on repair tracks for that purpose.

DELAYS CAUSED BY CAR PARTS, PERCENTAGE

Air brakes	26.00
Body work	17.20
Door work	2.90
Roof	1.50
Safety appliances	5.00
Trucks	12.00
Draft gears and underframes	14.00
Wheels, general	13.40
Wheels, slid flat	1.50
Operating conditions	6.50
	100.00

This indicates that defective air brakes and bodies represent the largest cause for taking cars out of service. Next in order are draft gears, underframes, trucks and wheels. Much has been said about the design of the body underframe, and the importance of a proper design is indicated by this statement. The trouble is usually experienced with cars which were designed and built from 8 to 10 years ago or longer. The character of materials in manufacture of wheels is a vital matter, as their renewal period is probably more frequent than should appear necessary, considering that they have a life of about 60,000 miles only. The betterment of designs now being worked out is with a view towards reducing the frequency of attention to vital parts, and while this may add to the initial cost of the car, this increase is very small in proportion to the resultant maintenance expense and serviceability of the car. Where 5 per cent or less of the cars are out of service for repairs the condition is considered somewhat normal and it may be generally understood that this factor is not as great in the retardation of car movement as terminal handling. Expressed in another way, carriers having a long haul per ton are, as a general rule, more prosperous than those having a short haul per ton. The frequency of terminal handling is, therefore, to be considered more seriously than maintenance at this time.

Depreciation and Retirement Factors

The problem of proper freight car utilization and maintenance is not solved merely by low unit cost for repairs or even by a large car supply. For instance, if 50-ton box cars will carry the prevailing grain tonnage, and if that represents a majority of the business offered, such class of equipment should be employed to save track room as well as detailed maintenance and make it possible to retire two old cars for one moderate unit. If an economical unit cost is to be attained constantly, it is necessary to consider the rate at which obsolete cars are retired and new ones acquired to maintain a proper complement of equipment. Take for instance the case of an administration applying the following rates of depreciation to their freight train cars:

Period	Rate of depreciation
Prior to July 1, 1907	(Charged profit and loss)
July 1, 1907, to Dec. 31, 1912	1½ per cent
Jan. 1, 1913, to Dec. 31, 1915	1 per cent
Jan. 1, 1916, to Dec. 31, 1920	2 per cent

In such a case these rates would be used merely to charge a certain amount to operating expense each month, based on the above percentages applied to the total amount in the investment account for freight train cars, and a corresponding credit would be made to "reserve for accrued depreciation," which is built up month by month. Under these circumstances, even where the highest rate of depreciation was charged at 2 per cent it would involve a total life expectancy of 50 years (neglecting salvage) and the manner in which this would affect a railroad, if it was desired to retire a car at 20 years of age, would be:

Original cost	$1,000
Salvage	200
	$800

From July 1, 1900 (date built) to July 1, 1907, or 84 months, the amount chargeable to profit and loss would be

$$\frac{84}{\text{Total, or 240 mo. (20 yr.)}} \times \text{(cost to date less}$$

salvage equals profit and loss	$186
From July 1, 1907, to Dec. 31, 1912, or 5½ years, at 1½ per cent on $1,000 less salvage	66
From Jan. 1, 1913, to Dec. 31, 1914, or 2 years, at 1 per cent on $1,000 less salvage	16
From Jan. 1, 1915, to Dec. 31, 1920, or 6 years, at 2 per cent on $1,000 less salvage	96
Total	$364

This means that at time of retirement a road so situated would have remaining to charge to operating expenses under the retirement account the following:

Investment	$1,000
Salvage recovered	200
Total	$800

Depreciation accounted for	364
Remaining to charge to operating expense	$436

Contrast this with another administration using a 6 per cent rate of depreciation; a parallel case would be as follows:

Original cost	$1,000
Salvage	200
Profit and loss	$800
(84 ÷ 240 × $800)	$186
6 per cent for 13.5 years	648
Accumulated	$834
To be written out	800
Over depreciated	$34

This makes a credit of $34 to operating expense and it might result in an administration following such a practice to permit the only factors taking equipment out of service to be physical condition and obsolescence, and under such circumstances the maintenance expense on a property so situated might run 25 per cent below that of the first administration unless retirements mere made regularly. In one case all charges would be made to depreciation; in the other case they would be split between depreciation and retirements, but both are in operating expense. In the first instance, in checking up the average age of cars held by various administrations, we find it ranging from 18 years to 35 years. It is important, therefore, to observe the policy of more frequent renewal and fewer heavy repairs or rebuilding, as it would seem to be more economical than extended life, and the accounting rate of depreciation, which is usually a straight-line rate, has a serious indirect bearing on the policy of maintenance which is employed. Proper turnover is the easiest and the most economical means of reducing repairs and overcoming obsolescence, because it is, in the end, very costly to extend the life of equipment to avoid the burden on operating expenses of writing out the equipment.

Aspects of Design

In 1901 the Pennsylvania Railroad built the first 50-ton box cars, because of their greater earning capacity over that of the 40-ton cars. An analysis of the real benefit in operating 50-ton box cars must take into consideration two important points. Can the greater loads they can carry be obtained? If so, what is the greater carrying capacity during a given period over and above the additional first cost, and the extra cost of hauling the extra dead load of the heavier car?

In view of the fact that many thousands of 50-ton box cars have been added to the equipment of the railroads in recent years and large numbers are now under construction for future delivery, it seems not inapppropriate to raise at this particular time the question as to whether the results obtained from the use of the 50-ton car in actual service will justify its extended employment in most localities as a standard car in place of the 40-ton car, or whether these results, when properly analyzed, will not show that the 50-ton car, from a practical or commercial standpoint, can only be regarded as a specialty confined to a particular class of traffic in a territory where the limits of its usefulness are governed by well-determined lines of demarcation. A proper and intelligent analysis of this subject necessarily involves a collection or compilation of itemized data on the essential factors that have a bearing or controlling effect on the relative value of this car compared with the others above mentioned. Among these most important factors are the following:

(a) First cost of car
(b) Capacity of car, cubic contents and car weight
(c) Average load carried in tons
(d) Conditions which militate against full load
(e) Cost of maintenance
(f) Extra cost of hauling additional dead weight when moved with less than full capacity
(g) Extra cost for maintenance of permanent way, bridges, etc.

An essentially fair comparison can be attained only by actual experience with a large capacity car under operating conditions and it should be borne in mind that such only tends to show the value of the car in the particular territory where it is in service and where the comparisons are being made. Therefore, it would be highly interesting and very valuable if a thorough and complete report could be had of the results obtained by the use of a given number of 50-ton cars in comparison with others, covering a period of two or three years, furnishing the exact figures and facts, that others who may contemplate the addition of new and heavier equipment may be better able to reach a correct conclusion in the premises as to the type of car best adapted for the locality through which their lines run.

Some observations of a general character may serve to emphasize certain points of more or less interest. The Union Pacific and Southern Pacific, two of the most prominent railroad systems in the West, have at present in service thousands of 50-ton cars, and it is interesting to observe that they have had in service cars of this capacity for more than 20 years. Such equipment, as a rule, is loaded to a point reasonably near its capacity, for the entire route over the owners' lines and this, of course, is what might be termed an unusually favorable condition of service for the 50-ton cars and gives them the place at once among the improved facilities that count for increased net earnings. As further evidence of this, an enumeration of some of the various commodities handled at different points on the line and the quantity in percentage of the car capacity which enter into the general average attained are as follows:

	Per Cent
Wheat	107.1
Corn	81.7
Barley	85.1
Other grain	100.4
Ore and bullion	114.6
Coal (largely in box cars)	84.0
Coal (open top cars)	106.0
Gravel	109.0
Beets	101.4

Economic Limitation of a 50-Ton Car

This affords an excellent insight, on the other hand, into the contention made by many that there is a special field for the 40-ton car which the 50-ton car cannot invade without a positive loss, either direct or indirect to the operating companies; and the field is the one where such commodities as hay, merchandise, mill stuff and miscellaneous products predominate and where conditions necessitate their movement in a manner to suit the shipper, regardless of the wish of the carrier. Furthermore, it is not within the range of possibilities for the carriers to educate their shippers so

as to secure the delivery of their traffic for movement at a time and in a manner that will permit a prompt and full car-load movement, at a specified time, of commodities of this character which will compare with the handling of ore, coal, grain and similar commodities which are regulated by the train load rather than by the car load, and which are offered for shipment at a time and in such quantities as not to require movements of less than the maximum train load.

The freight car mileage for 1925 was 26,729,831,000 miles; of this, 35 per cent was empty car mileage, which would indicate that many lines were operated under conditions where it was almost impossible to secure loading in both directions for their cars. While this is doubtless largely the case with roads that are essentially coal or ore lines, yet much of it is in the agricultural districts where the empty mileage is box car equipment, handling an average of about 24 tons per loaded revenue car. This would seem to warrant the suggestion, if not the conclusion, that a general utility car substantially built to meet all the physical conditions resulting from interchange service, with minimum dimensions of the American Railway Association's standard box car, of a capacity not exceeding 80,000 lb., is from some points of view not only the more typical, but more desirable commercially, physically and financially, as a common standard for American railroads than the 50-ton car; although the latter has been adopted on some of the most important trunk lines and by virtue of the interchange arrangements between various roads is not only in evidence on, but in some localities forms a no small percentage of the cars on the line, which would otherwise favor 80,000 lb. capacity equipment.

It seems rather inconsistent, from a business and commercial standpoint, that large trunk lines should spend enormous sums of money in perfecting their permanent way, and other facilities for handling their business, and also equally large sums in the purchase of motive power and equipment which is peculiarly adapted to their line and meets with the view of their officers, and then a large portion of this equipment should be diverted into a class of traffic and on to lines where the conditions are at considerable variance to those which hold directly opposite views as to its commercial value as an operating unit and as to the practicability of its use. While much of this modern heavy equipment is found on roads whose officers question its adaptability to the conditions which they have to meet, at the same time a no less conspicuous feature of what might be termed unbusinesslike conditions that result from the interchange of cars is the presence on the large trunk lines, which have adopted the modern heavy car, of a great number of small antiquated cars belonging to the lines which do not favor the use of the large car. Many of these small cars were built years ago when the tractive power of freight engines averaged about 35,000 lb. and the original construction of the cars was light. This, together with their age, renders their physical condition such that in some cases they are scarcely safe for service in light trains on local runs and are absolutely dangerous when placed in modern heavy trains handled by large types of heavy freight engines; dangerous not only to the cars themselves, but in case of accident, as a rule they are not only badly damaged but are the direct or indirect cause of destruction of the modern heavier cars with which they are intermixed in train service. The high cost of repairs to freight cars, on some lines, can be traced to the retention in service in some cases of light antiquated equipment that should have been retired from service immediately following the advent of modern car construction.

The more highly developed a railroad becomes in providing fast passenger service and regular and profitable freight service, the greater is the necessity for the use of good materials to prevent accidents and provide reliability of movement. When such services are offered to the public, there is imposed a moral responsibility to furnish materials which shall be equal to the service requirements.

Generally, coal cars returning empty to mines make substantially the same number of empty miles as is made on the loaded haul. There should be a decided saving in operation where larger cars are used. Furthermore, if there is a continued shortage of coal cars at mines in competitive territory during peak business, there would be a further gain in net revenue as a net result of whatever percentage of increased load obtained. Assuming the net earnings per day, over and above all cost to handle, is one dollar on a smaller car, then with a larger car representing a 25 per cent increase in carrying capacity, this net would be increased to more than $1.25 a day. If the car requires ten days to make the round trip, the increased revenue would, at least, be more than $2.50 (cost does not vary directly with capacity and the net saving will be more) for the round trip and would probably result in a substantial net return from the additional net revenue on the additional investment required to be made for the larger cars, providing the peak movement under these circumstances existed during 40 per cent of the yearly period.

Design Cars for Service in Which They Will Be Used

In designing a car, the service in which it is going to run must be considered, not the service in which it may run. One of the advantages given for all steel, steel underframe, and steel framed cars, is that train resistance is less than with wooden cars. The principal reasons for expecting a lower resistance with a steel car are: First, on account of its greater rigidity there is less deflection in the bolsters, and the side bearings are not in contact under the maximum load; hence, there is less flange friction and a lower tractive resistance. Second, the capacity of steel cars is so much greater than that of wooden cars that it is possible to haul the same tonnage in one-half or two-thirds the number of cars, and it has been found that the increase in train resistance for a given total tonnage increases with the number of cars required to equal that given tonnage. This is to be expected from the greater area exposed to atmospheric resistance and because of the large number of wheels producing flange friction. With equal coupler clearance on straight track, there should be no difference in the resistance of the wooden and steel cars, so far as the drawbars are concerned, but on the curves the rigidity of the steel draft rigging prevents the coupler from accommodating itself on the normal line of the pull, and if the clearance is too small the wheel flanges are forced against the rail, thus increasing the train resistance. With the wooden car, however, the draft timbers are easily displaced or compressed and the bolts in the wooden draft attachment work to one side and the whole rigging gives enough to provide a movement of the coupler equivalent to greater clearance and is sufficient to prevent undue flange friction.

The foundation of economic efficiency in freight-train service is the utilization of each car to its fullest capacity, and the first step in this direction must be taken at the origin of the traffic. The latter points, for the most part, when considered west of Chicago, are in isolated sections, not lending themselves easily to intensified supervision. It is essential that cars be in proper condition with respect to wheels and air brakes before loading, because far too many refrigerator and oil-tank cars are unnecessarily delayed under load for wheel changes, and for defects which

should have been discovered and corrected at the last repair point before loading.

Freight cars are used in common under the A.R.A. car service rules, the per diem agreement and the interchange agreement. They are repaired (with certain exceptions) on the road where the need for the repairs develops. The average freight car of an individual road is at home not much more than one-half of the time. Obviously, if there is a common standard for the types of car used for the great bulk of the interchanged traffic, each road will be required to carry a much smaller stock of repair parts, and there will be a reduction in the time now lost by cars which are held while the repairing road is obtaining parts of special design.

Net tons per car load seem to remain stationary in the face of improvement in practically all other factors such as net tons per car day, car miles per car day, freight locomotive miles per locomotive day, freight cars per train, gross tons per train, and net tons per train, and average speed of freight trains. Empty car miles seem to increase by reason of better performance on the part of carriers. This situation indicates that where an improvement in other directions obtains, a decided increase in the percentage of empty mileage will result, and the sole reason for having an increase in the percentage of empty mileage comes from the fact that administrations are at present moving empties promptly, whereas when they had a low percentage of empty mileage the empties were standing still and there was a shortage of cars. It is felt by the best authorities that as long as we continue to make an improvement in the movement of business we are going to show an increase in the percentage of empty mileage compared with periods when the movement was not so prompt.

The Problem of Unproductive Weight

To whatever extent the unproductive weight of the train can be diminished, to that extent the productive weight may be increased by the absorption of the same amount of energy of locomotive tractive power without reduction in rate of speed. It is, therefore, an element of efficient use of tractive power, from a business point of view, that the dead-weight proportion of a train shall be maintained at the lowest point consistent with reliability in performance. If we were to consider the cost of hauling 800 pounds (avoidable) additional weight per car, because of using a certain feature of design instead of another of equal engineering value, and in order to save the extra weight it was necessary to pay $60 extra per car in first cost of the car, and the maintenance features were not affected, the problem would work out as follows:

Average miles per car owned per day (includes bad orders).......	28.3
Cost of hauling one ton of dead weight one mile by Class I Railroads varies largely from $0.004 to $0.007, so that by using the mean figure, it should be considered acceptable......................	$0.0055
Considering 6 per cent bad order cars would mean 94 per cent of 365 days in service or..	343

Therefore, 800 ÷ 2000 × 343 × 28.3 × 0.0055 = $21.36 per year, or years to pay = 60 : 21.36 = 2¾

It should be understood that any figure used, such as $21.36, is more or less theoretical, since the cost of hauling per ton of weight is not directly proportional to the weight carried but rather the relation of full tonnage possibilities to actual tonnage hauled. A carrier having full tonnage trains will have a lower cost per ton-mile than one with variable loads of less than full tonnage.

Conclusions

The function of mechanical budget allowances is very often controlled from decisions made by officers other than those who are actually held personally accountable for the results. These decisions, respecting maintenance procedure, are based upon available funds or immediate earnings or prospective needs, to cope successfully with the present or future business and quite often neglect adequate consideration for economies from steady employment. Those who immediately direct should be cautious of the programs governing the handling of the work, and the time rate of output, so that the facilities may be, in so far as possible, loaded to an economical range of working. This is not as simple as it might at first appear. The budget of requirements should be worked out by forecast, plus experience and adjustments. A yearly allotment should be worked out, the same being based on a policy of procedure covering a term of years, as this is an absolute essential to intelligent and businesslike management. Estimates should be made in advance for each month, and the various items tabulated on a budget sheet which can be laid out to accommodate as many divisions of the work as are required. The big underlying principle of budgeting has regard for the needed advice which must be given the purchasing and stores department in advance so they can make the material supply coincide with a policy of steady employment of man-power in so far as possible, all with a view toward a businesslike and economical procedure.

The following topical suggestions are offered in closing: Railroads are going concerns not subject to being closed down at a moment's notice, consequently—

(*a*) They should systematically consider the current requirements of the service as they become increasingly apparent from year to year in view of enlargements in traffic and the ever changing conditions of operation.

(*b*) Maintenance policies need to be formulated far in advance, in order to currently maintain and turn over a proper number of cars by classes, also to employ at least complement of facilities and labor force regularly to keep the entire plant structure working efficiently and uniformly to the greatest reasonable degree and, yet, with a maximum economical output.

(*c*) Adhere to a 20- to 25-year life for freight-train cars with an annual depreciation rate to coincide with whatever figure is used and provide for suitable and current replacement.

(*d*) They should procure freight train cars when built new embodying design fundamentals recommended by the A.R.A. and of minimum weight consistent with traffic and engineering considerations.

Japanese Railway Men to Study American Railways

A group of eight Japanese railway officers recently arrived in San Francisco, and departed for different sections of the United States and Canada to begin a twelvemonth study of American railways. Chikano Oinouye, chief engineer of the Shimonoseki division of the Japanese Government Railways will study under water tunnels. The Japanese railway is planning a tunnel from the island of Honda, the main island of the Japanese group, to the island of Kuyshu, the southern island. The tunnel will be over a mile in length and about seven fathoms under water, while the cost will approximate $15,000,000. K. Hashima, who is on the engineering staff of the Kokkaido Railways on the northernmost island of Japan will study snow-fighting. G. Kurata, construction engineer of the government railways will make a study of construction methods employed in the United States, and K. Haginura, assistant chief engineer in the architectual division, will devote his time to railway buildings, while T. Kayakawa will study traffic. T. Ohtsubo and Mizao Tetsuka, attorneys, will devote their time to management.

Canadian National Railway Builds Two Mikado Locomotives

The Canadian National Railway recently built two Mikado type locomotives at its Point St. Charles shop, Montreal. The locomotives are somewhat of the same design as the Mikado type locomotives already in service, except that these are equipped with feedwater heaters, boosters, and larger tank. The new locomotives were placed in freight service in the Atlantic region.

The boiler is of the extended wagon top type, and is equipped with Nicholson Thermic syphons. The grates are of the Canadian National standard type, with dump grate at rear on right hand side, and are operated by Franklin power grate shaker, with the exception of the dump grate, which is operated by hand. The ashpan, owing to the limited space under the firebox, caused by the application of booster, is equipped with a hopper of special design, and double doors with hinges located so that the doors will close of their own weight. The ashpan is fitted with a sludge arrangement consisting of a $1\frac{1}{4}$-in. pipe extending from the inspirator delivery pipe to the ashpan, with valve operated from the cab. The superheater is Schmidt type A, with through bolt header and forged return bends. The smokestack is the Canadian National standard 3-piece type, the center piece forming the base and fitting to the smoke box. The stack proper extends down into the base and butts against the stack extension, which fits over the barrel netting. The latest type of barrel netting has been applied, providing for ease in getting at the superheater units. The driving wheels, 63-in. diam., have 56-in. cast steel centers. Main and back driving journals are 11 x 13 in. and other driving journals 10 x 12 in. Franklin adjustable wedges are applied to all driving boxes, and the main and back driving boxes are fitted with Franklin spreaders. The rear end is fitted with a Commonwealth cast steel cradle casting. The trailing truck is of the constant resistance type with 43-in. diam. wheels with 36-in. cast steel centers. The main rods are of the solid end, floating bushing type. A duplex stoker is applied, and the boiler is fed by Elesco type K-31 feed water heater with constant flow pump, left side, and by a Hancock type H.N.L. inspirator with 5,000-gal. tubes on the right side. Steam distribution is provided for by Baker valve gear, controlled by Franklin Precision power reverse gear. Diameter of valves is 14 in. and travel is $6\frac{1}{2}$ in. Valve lap is 1 in. and lead $\frac{1}{8}$ in. Exhaust lap and clearance are nil, the valves being set line and line. The cylinders are of Canadian National standard design and are fitted with Canadian National standard bypass valve and 3 standard cylinder cocks per cylinder, one at each end of cylinder barrel, and the third in center of barrel, connected with a drain pipe from bottom of steam chest. All 6 cylinder cocks are operated in unison by one lever in cab. The exhaust passage is drained by four 1-in. pipes, one in each cavity, leading into a $1\frac{1}{4}$-in. pipe provided with a $1\frac{1}{4}$-in. valve placed in front of cylinder. Cylinders are equipped with Canadian National standard relief valves.

Mikado Type Locomotive Built in the Shops of the Canadian National Railway

The cab is of the Canadian National standard short vestibule type, of steel construction, wood lined and asbestos insulated. It is fastened securely to boiler and running boards, and provision is made for expansion where secured to cab brackets. The cab turret is of Canadian National standard type, placed outside of the cab, and far enough removed from it to allow of packing the operating valves. The sand box is fitted with Hanlon sanders, and sand is piped to the front of the leading drivers and the rear of the trailing ones. World safety valves, one muffled and two plain, are applied. Headlight equipment consists of Pyle National K-2 turbo-generator and Keystone copper cage, fitted with 14-in. Golden Glow reflectors and C.M.S. focusing device. King metallic packing is used on both piston and valve rods. Franklin spring type radial buffer and Unit safety bars are used between engine and tender, and piping between engine and tender is fitted with Barco points. The firebox is fitted with Franklin No. 9 firedoor. The cylinders are lubricated by Nathan 4-feed mechanical lubricator, and a

Detroit 3-feed hydrostatic lubricator in the cab supplies oil to the air pump, feedwater heater pump and stoker. The booster is lubricated by a Nathan 6-1 Bullseye lubricator. The latest type Canadian National steel pilot is applied.

The tender is of the water bottom type, designed for application of Duplex stoker. Water capacity is 8,300 imperial gal., and coal capacity 15 tons. The tender has a Commonwealth cast steel frame. Tender trucks are of the 4-wheel pedestal type, equipped with 34¼ in. wheels with semi-steel center 28-in. diam., and journals are 6 x 11 in.

These two locomotives were completed in September, and are in service, where they are proving very satisfactory. They are similar, as regards general dimensions, etc., to the S-1 class of locomotives operated for a considerable time on the Canadian National.

The boiler is of the extended wagon top type, and is equipped with Nicholson Thermic syphons.

The general dimensions are as follows:

Gage	4 ft. 8½ in.
Weight in working order on engine truck	26,200 lb.
Weight in working order on drivers	226,090 lb.
Weight in working order on trailing truck	59,450 lb.
Weight in working order on total engine	311,740 lb.
Weight in working order on tender	191,200 lb.
Wheel base, driving	16 ft. 6 in.
Wheel base, engine	35 ft. 9 in.
Wheel base, engine and tender	68 ft. 2 in.
Driving wheels, diam	63 in.
Boiler, outside diam., first course	74 in.
Boiler, outside diam., largest	83 in.
Boiler, working pressure	180 lb.
Firebox length and width	108⅛ × 75¼ in.
Tubes, no. and diam	213—2 in.
Flues, no. and diam	32—5⅜ in.
Length of tubes and flues	20 ft.
Heating surface, tubes and flues	3,117 sq. ft.
Heating surface, firebox, arch tubes and syphons	295.4 sq. ft.
Heating surface, total	3,412.4 sq. ft.
Grate area	56.5 sq. ft.
Tractive effort without booster	53,100 lb.
Tractive effort with booster	63,770 lb.
Cylinders, diam. and stroke	27 × 30 in.
Factor of adhesion without booster	4.26
Factor of adhesion with booster	4.47
Limiting height	15 ft. 3 in.
Limiting width	10 ft. 10 in.

Railway Business Association Meeting and Dinner

The Railway Supply Industry and Future Railway Progress are Discussed

The Railway Business Association held its annual meeting and dinner at the Hotel Commodore, New York, on November 18. Alba B. Johnson, president of the Association, presided. The 1,500 diners representing the leading railroads and railway supply companies were addressed by Whitefoord C. Cole, president of the Louisville & Nashville, and Simeon D. Fess, United States Senator from Ohio.

At a business session held in the forenoon of the same day a paper entitled "The Future of the Railway Supply Industry," was presented by Roy V. Wright, managing editor, *Railway Age*. A conference report from the executive committee of the association entitled "Problems of the Railway Supply Industry," was also presented. In the discussing of this report, A. C. Moore, vice-president of the Chicago Railway Equipment Company and A. H. Mulliken, president of the Pettibone-Mulliken Company, contributed papers dealing with "Railway Attitude Toward Progress and Quality," and "The Policy of Railways Towards Prices," respectively.

The addresses of Mr. Cole and Senator Fess appear in the following pages:

The American Ideal

By WHITEFOORD R. COLE, President, Louisville & Nashville Railroad

The Transportation Act of 1920 was enacted. It is my personal opinion—however, I know that some railroad executives disagree with me with respect to this—that it is the most enlightened piece of legislation, either state or national, that has yet been enacted, with respect to the regulation of these great systems of transportation.

I won't take your time to discuss that Act in detail. There were many and varied provisions, including the extension of the Interstate Commerce Commission's authority over such matters as the use of joint facilities, the financing of railroads, railroad consolidations, and labor questions, etc., but the heart of that Act, and the thing that gives to me, and I think to most people, hope, is Section 15a, which is the rate-making provision of the Act. In that provision, for the first time, there was wrought into our national policy the theory that not only must transportation rates be reasonable for the service performed, but they must be sufficient to maintain an adequate and efficient system of transportation.

To be sure, substantially that had been the common law all the time, but for the first time there was wrought into a statutory enactment a provision to that effect. That provision is simply this, as you all know, that the Interstate Commerce Commission, in exercising its powers to fix what may constitute just and reasonable rates, shall so fix those rates that under honest, efficient and economical management, the railroads of this country shall be permitted to earn a reasonable return on the value of the property devoted to public service, leaving in the hands of the Commission the power and authority, not only to fix the value upon which such returns may be earned, but the rate of return itself. Can anyone be heard to say that that is not a reasonable, and a fair, and a just provision of the law? To say that such is not the case is the equivalent of saying that the railroads ought not to be permitted to earn a fair and reasonable return on the value of the property devoted to the public use.

But the law does further than that. It provides this rate-making scheme with respect to the railroads as a whole, or in such groups as they may be divided into by the Commission for rate-making purposes, but when it comes to dealing with the individual railroad, it provides that, should any railroad earn more than six per cent on the value of its property, then one-half of that excess earning must be turned into the treasury of the United States. This is the so-called "recapture clause." That provision of the Act has been described throughout the length and breadth of this land as constituting a government guarantee of earnings. It is absolutely nothing of the kind. A guarantee implies a guarantor, and if the United States government had been guaranteeing 5¾ per cent, which the Commission has fixed as the reasonable return

on railroad property since the effective date of the Transportation Act, the government would owe the railroads of this country hundreds of millions of dollars, and if there is any such guarantee in effect, I should like very much to collect my part of it.

All Records Broken

It is astonishing that there should be iterated and reiterated as much misrepresentation as there has been about this eminently fair provision of the Transportation Act. As to the results of the operation of this Act, I think they have amply justified it. I point you to the unparalleled transportation performance of the railroads of this country for the last three years, when in each of those years, and in almost every month, the railroads have broken all previous records in the handling of tonnage, without congestion, and without appreciable car shortage, or any of the attendant evils that we have been so accustomed to for many years prior during periods of extraordinary activity. To this result numerous causes have contributed, of course. The underlying one is the something like $4,000,000,000 which the railroads have spent in the last six and one-half years in the improvement of their facilities, largely out of funds borrowed on the faith of the national policy as expressed in this Act. A second and important contributing factor is the improved esprit de corps of the employees of the railroads.

Last, but by no means least, is the wonderful co-operation which the railroads have received from the shippers throughout the length and breadth of this land, without which this transportation performance would have been impossible. I call your attention also to the tremendous and necessary effect on the prosperity of the country that these enormous expenditures for additions and betterments has meant. The railroads are the largest single purchasers, certainly of some classes of raw materials, and taken as a whole, they are the largest purchasers of all classes of raw materials in the country.

This comprehensive piece of legislation is not perfect. Few human instrumentalities, if any, are. But it represents a tremendous advance in the scientific regulation of the railroads. It could be improved on. I suppose everybody in the room has got some idea he feels would represent an improvement in this legislation. I know I have one, and that is, if this recapture clause is to be retained in the Act, it should be so amended that not a single year's operation of a railroad would be the yardstick as to the application of the recapture provision. Inevitably, if that policy is pursued, it will result in the railroads earning less on an average than the statutory rate of return; because if one of them reaches or exceeds 6 per cent, it must give up one-half of those earnings. Of necessity there will be some years, as most of the years since 1920 have been the case, when they will earn less than the 6 per cent, and thus the average will fall of necessity below the statutory rate of return. Therefore, I think if this provision is to be retained in the Act, it should be amended so as to provide that three or perhaps five years' earnings should average 6 per cent before the recapture clause becomes effective.

Railroad Baiting

It was hoped, when this piece of legislation was enacted into law, that it would definitely remove the railroads from the field of politics, much in the same way that the enactment of the Federal Reserve Law did remove banking from the political field. But the lure of railroad baiting has proved too strong for some of the politicians of the old school. They have not yet learned that the American people understand the railroad problem. I do not like that word "railroad problem." It sounds too much like the drink problem. But they have not yet learned—some of these politicians of the old school—that the American people, taken as a whole, have a very much better understanding of the railroads, and their managements, and their personnel, and their aspirations and hopes, and what they are attempting to accomplish in behalf of the people of this country, than they used to have. I am not saying that in the old days of railroad baiting, when it was really a popular and profitable pastime for politicians, railroad managements were altogether faultless. It is a long way we have come since the old days. The books of these railroads are open books.

The executives of these railroads take their friends and their patrons in the territories they serve into their confidence, and the public need their confidence. They have no secrets. It is the most closely regulated business on earth. I have sometimes thought that in view of the fact that the government fixed the rates, which of course fixes the income of the railroads, and largely fixed the prices they must pay for labor, and they had to buy everything else in the open market, when market conditions fixed the price of things, I have very often thought that the average railroad president did not have much to do but to hunt up the money with which to pay the deficits. That is not altogether true, certainly not in the last two or three years. The sun of prosperity has been shining on them to a reasonable degree, as a result of this more enlightened policy. In the last session of Congress 200 bills were introduced, affecting every phase of railroad operation, apparently from the most trifling things to measures that seemed to aim at their destruction. It is creditable to the good sense of both houses of Congress that substantially few measures of this type got through, but it shows that the railroad baiter is still to some extent around on the job, although I do not think he finds it as popular a pastime as formerly. The most imminent danger that is affecting the railroads today is the tendency being exhibited in Congress from time to time towards direct legislation by Congress on rates and practices of railroads.

Legislative Rate Making

Congress is a great deliberative body. They deliberate right sharp, and it is all right for them to deliberate, and they have to legislate, but when it comes to the fixing of the rates and to that complex thing that we know as the rate structure, it is not a thing that can be safely dealt with in a great deliberative assembly of that kind. The national policy has very wisely confided that important and responsible task to a body of experts in the personnel of the Interstate Commerce Commission, and that is where it should be allowed to remain. Attempts at direct legislation on these questions inevitably will result in a political rather than an economic consideration and determination of these questions.

Take attempts that have been made to enact laws designed to reduce rates on specific classes of commodities like farm products. I yield to no one in my genuine anxiety to see as important a part of our body politic and our economic structure as the agricultural interests placed on a firm foundation and one of lasting prosperity, but there is no foundation in law, nor justification in economics, why something should be taken away from one class of our citizens and given to another, based solely on the necessities of the second class. I do not care who they are, whether they are farmers or anybody else. That is a dangerous doctrine to introduce into the administration of law in this country. If it is wise and proper and just, when the price of farm products is low, provided always that the rate is a reasonable and equitable one, to reduce freight rates for the farmer, because of his necessity, by the same token why should not rates be reduced on coal,

when the price of coal is low, and on steel, when the price of steel is low? That whole idea and the result of that is that the railroad inevitably becomes the victim, and it as a whole is bound to suffer, because there is nothing that this country needs, requires and must have, more than the maintenance of an adequate and efficient system of transportation. No, the farmers' problems cannot be solved by taking money that justly belongs in the railroads' pockets out of their pockets and giving it to the farmers. There is always somebody standing around, ready to tell the farmer his trouble is due to high freight rates; but it is not due to anything of the kind.

Farmers' Troubles Not Due to Freight Rates

A recent study by the Bureau of Railway Economics clearly discloses the relationship between freight rates and various farm commodities. It clearly disclosed that the price of wheat, at primary markets, has frequently fluctuated in the period of 24 hours more than the entire freight rate from certain points to those primary markets, with the result that one farmer, shipping his product today, with the price of wheat high, paying the full freight rate, gets more net for his wheat than another one shipping it tomorrow if it had been transported free of charge.

Now, the farmer's plight has been a serious one, and he has had lots of trouble, but his troubles have not been due to high freight rates. I think I know what some of his troubles are. I haven't got time to tell about all of them tonight, but in my opinion the underlying trouble of the farmer has been that he is producing everything that he has to produce, and selling it under conditions when the unrestricted law of supply and demand is in operation—substantially so. There are a few exceptions to that. Some of these farmers' co-operative organizations have been efficient and effective instrumentalities, but in the main the great mass of the farmers of this country, and the great mass of agricultural production of this country, is marketed under conditions where the unrestricted law of supply and demand finds full play, and the things that he has to buy are bought in markets where artificial restrictions are thrown around the laws of supply and demand—for instance, by wage agreements, which are not based on the supply of labor or the demand for it, but made matters of agreement between employers and employees.

"Oh, well," they say, "you cannot apply that doctrine to labor; labor is not a commodity." Well, no. Labor is not a commodity in the sense that you cannot separate a man's labor from his personality, and that there is a human equation there; but if labor is not a commodity, you will agree that a bushel of wheat is a commodity, and what is a bushel of wheat but the farmer's stored-up labor?

Now, what the farmer needs to do is not to be eternally casting his eyes towards Washington, like he was turning his face towards Mecca. That is not the American idea of doing things. I am getting so awfully tired, every time any problem comes up in this country, of seeking a legislative solution of it at Washington. The conception of our American institutions is the right to life, liberty and the pursuit of happiness, according to a man's own free will, so long as he does not do any harm to his neighbor. It is not legislative relief that is needed, so much as awakening a direct sense of responsibility on the part of the individual to work out his own salvation, in company and in association with his fellows, and the relief of the farmer is going to come along the lines of co-operative activity. Let him take a leaf out of the book of the labor unions and the trade associations. Let him put up a solid front and make us pay for the things he has to sell, like we are making him pay for the things he has to buy.

Now, while I am on the subject of direct legislation, I want to give you another illustration. Take this so-called Pullman surcharge. Now, I think that is the most unfortunate term that was ever employed to designate anything, to call that a Pullman surcharge. It is a very unpopular thing, particularly to people who have not analyzed it. In reality it is a charge for a preferred service. It affects a comparatively small percentage of the total passenger travel of the country. And it means $40,000,000 a year to the railroads.

The question of the abolition of the Pullman surcharge was before the Interstate Commerce Commission, and after months of hearings that body decided adversely to it, and the very first crack out of the box representatives of commercial travelers' organizations undertook to get Congress to over-ride this body of experts. The Commission had decided that the railroads needed this revenue; that it was a reasonable charge, and that if it was taken off, it would have to be supplied from some other source. The first move they made was to go to Washington to get Congress to over-ride the Interstate Commerce Commission. God grant that Congress will have strength of character enough to decline to do any such thing. The Congressional Record disclosed that in the discussion of that matter the Committee of the Senate which had reported that bill favorably were all apparently under the impression that this surcharge was collected for the benefit of the Pullman Company and paid over to that company. One grave Senator asked the Examiner whether it was true that the railroads were collecting this surcharge and turning it over to the Pullman Company, and if that were true, how could it be legal, since the charges of the Pullman Company were fixed under the tariffs that had been filed with the Interstate Commerce Commission.

That is the kind of treatment that these great questions which vitally involve the lifeblood of the railroads of this country are likely to receive when it comes to direct legislation on transportation rates. It should be left precisely where it is, in the hands of the Interstate Commerce Commission, without political inter-meddling.

Now there is a great deal of talk about high freight rates. Freight rates are high, compared with what they were before the War, say in 1913 or 1914. Varying with the section, they are on an average from 40 per cent to 50 per cent higher, but why shouldn't they be higher, when everything that the railroads have to buy is from that percentage on up higher than the pre-war prices? When you say freight rates are high, it is a relative term. I think you can buy substantially as much transportation for a dollar as you can of nearly anything else.

Buses and Trucks

Now, I do not think that the railroads should stand bound, with their fingers in their mouths, and decry the hard lines they have fallen on, because they are being competed with by buses and trucks. I think they have got a reasonable ground for complaint if the highways, that were built at public expense, and out of taxes contributed partly by the railroad, are permitted to be used for common carrier purposes, without a proper contribution and reasonable sharing of the burden of construction and maintenance of these highways by the interests which use them for common carrier purposes. I think the railroads have a reasonable cause for complaint when communities insisting on railroad service being maintained for what might be called purely ornamental purposes insist on using another form of service. I think the character of service to which the trucks and buses are best adapted had better be performed by them, to the exclusion of the railroads. There is apparently an evolution in the process of transportation, particularly over short hauls, which has commended itself and has been found desirable by the Ameri-

can people. We cannot undertake to say that we want to stop that process of evolution. We had better go into the truck and bus business, although I believe the Governor of Pennsylvania has declined to let a railroad or two have franchises to operate buses on the ground that the railroads would get a monopoly of them.

Too Much Government

By SIMEON D. FESS, United States Senator from Ohio

In considering railroad measures the legislator must recognize the interest of the management, also the interest of the owners, also the interest of the employees, but in addition to all that he must recognize the interest of the larger party, which is the public; and as a legislator upon the committee that has sent to it hundreds of proposals for modifications of the legislative status of the railroads.

I know about the effort to repeal the surcharge. I understand the ground upon which it is put. I respect those who are making the effort. But I have never agreed with them. Until we can find some other revenue to take the place of the $40,000,000,000, I do not see how the surcharge can be repealed, and for that reason I have continued to oppose it. I respect the people who insist upon regionalizing the Interstate Commerce Commission, on making it a body representative of the various localities of the country. Some men in the Senate insist that the Interstate Commerce Commission must represent the various sections of the country, and we must pass a law, requiring the President, when he makes the appointments, to make them from specific sections.

While I respect the judgment of these men, I think one of the most fatal things we could do would be to plunge the Interstate Commerce Commission into something like a pork barrel. And I therefore insist that the Interstate Commerce Commission must be a national body, in which its interests are for the public at large, rather than for any particular section.

Opposes Legislative Rate Making

There has been a tremendous agitation to deny to the Interstate Commerce Commission its power over Section 4, the long-and-short-haul clause. I am perfectly familiar with the argument, and it seems to me that on the face of it, there should not be a smaller charge for a long haul than a short haul, but if that is to be done, if it is to be prevented, it should not be by the order of Congress. It should be by the order of the Interstate Commerce Commission, where it belongs.

The question that is before us now in the form of a simple resolution is a declaration that agriculture is a staple article or a staple industry. Of course it is, without saying so. Saying so by legislation does not make it more so than it is. The reason that resolution was passed was to get relief for agriculture. I recognize the tremendous basic importance of agriculture. The basic occupations in America are agriculture, transportation, mining and manufacturing, banking in various forms, managerial ability in directing industry, and labor. What a wonderful position America has, when we analyze the strength of the country from those elements. There is no such thing as general prosperity if any one of these basic industries is depressed. To have the general prosperity for which all of us are working there must not be any one of these under the handicap of depression if we can relieve it. Therefore, agriculture commends our attention, and ought to, in a sympathetic way.

Some of the agitators hold that the way to relieve it is the reduction of the freight rates on agricultural products. I have some sympathy with that point of view, provided that the necessary revenue of the roads can be supplied without detriment to other industries. I am of the opinion that the rate structure can be revised. I think that there is no difficulty in reducing freight rates upon certain articles, if we can add the freight rate to other articles in which there is much value in little space. It has been suggested that that would be benefiting one industry at the expense of another, but I do not believe a revision of the rates on things like silks and the like would increase to the detriment of the purchaser the price of the article. We might reduce the freight rate upon agriculture and increase the freight rate upon other articles without hurt to the public or to the railroads. But the only way it could be done would be under a system where the reduction from one road, which might be altogether agricultural, might be made up by the increase on another road, where the road itself does not need the increase, and that would have to come through a revision of the rate structure. But nobody here would believe that I think that the revision should be made by Congress.

Problem Must Be Met

A demand is made for the lowering of freight rates on agriculture as a remedy or relief for this depression. On the whole this could not have a great effect; but that does not change the psychology of the situation. Where a demand is being made in a democracy like ours, a problem cannot be suppressed; it must be directed. And I say to the men interested in transportation here, that the problem of transportation in products of the farm is one that has got to be met. If it can come through a revision of the rate structure, and that revision be made by the experts of the government, in consultation with railroad men, then it may be safe, but it must not be done by the politician at Washington.

Everywhere it is stated that we have guaranteed an income to the railroads. To me it is a surprising thing that in the face of the fact that there was only a guarantee for a short space of time, following the return of the railroads to the owners, we hear in Congress every day from responsible Senators that we guarantee a profit to the railroads, therefore you must guarantee it to the farmer, or you are discriminating against the farmer.

It was that kind of argument that led me to suggest to some of the railway representatives that it might be wise for us to repeal the 15a provision, because in 15a there isn't a thing, outside of the announcement of a policy, and that is that there should be reasonable income upon the valuation of the property. There is another thing in 15a that most people do not want, the recapture clause, and that is the only thing in the section that the Interstate Commerce Commission could not do without it. The only thing 15a says about income is that it is the policy of the government to permit a reasonable income or return upon the valuation of the property. It says nothing about what income would be reasonable. That is left wholly to the Commission, and the Commission could do that thing without 15a if it wanted to. The railway managers point out, however, that if we would repeal that, it might be a

repeal of the policy that a reasonable return on their investment should be permitted.

Government Ownership

There is a phase of legislation which in my opinion ought to command your sympathetic attention. You may believe because of the unfortunate experience during the World War with government ownership we shall never again be forced with the danger of government ownership. Better disabuse your mind of that idea. It is not entirely eradicated from the minds of the American people. There is a feeling, not among the responsible citizens, but pretty widespread, that if we had government ownership, and there were any profit, the government would get it, and if there weren't any profit, then the government could stand the loss.

So far as I am concerned, I am through with government ownership for the balance of my life. We had experience enough during the War. The demand for it will never have any effect on me.

Transportation is absolutely essential to maintain our present industrial and social life. You can do without some things, but not transportation. The country would starve, the country would freeze, if transportation should stop. Transportation must go on. It will go on. It does not make any difference how much loss will be suffered, it will go on, and if private enterprise cannot do it profitably and without interruption, the government will do it. If it ever comes to the point where, from any reason, private ownership cannot continue the running of any essential line because it is paying out more that it is taking in, that line will run anyway, even if it has got to be run by the government.

The basis on which government ownership is going to be demanded is the weak lines. There is before us now the proposal to permit rail properties to consolidate, so that the strong line may have attached to it a weaker line. The weaker line will be a feeder of the strong line, and the weaker line attached to the strong line might be more profitable than when it is independent. That is easily conceivable. I presume that is possible.

There is a bill on the Senate calendar to permit the railroads to consolidate under a limited number of systems. The only feature of that bill is that it gives two years for the roads to make the consolidation, and if they do not do it within that time, then the government is to step in with a penalty to advance it or to expedite it. That is the feature I do not like. I am of the opinion that railway consolidation would be advantageous, if it can be done under natural evolution, but not by Congress.

Another bill will eliminate the compulsory feature, and I think we shall have some chance—not in the short session, but ultimately—of seeing it become a law. Though railway people do not like it generally, I am of the opinion that it is a better substitute than government ownership, which I am afraid of, unless something of this sort is carried out.

What the people want this year they do not want next year. Railroading is a subject of baiting. It is a football. The politician who thinks that "My people want this thing," is going to do what he himself believes is unwise, simply because he thinks it is a popular thing to do. There is our danger. If we believe that a growing country like ours cannot continue unless we have a sound transportation system, then it seems to me that we ought not to join every group that wants to bait the railroads.

America is great because transportation is great. All legislation should be limited, not to baiting the railroads, but to giving them a greater chance to continue their expansions and their improvements, to keep up with the growing needs of a mighty country. You can do it without being "a railroad Senator"—you can do it because you are a representative of the best interests of the people, and you cannot represent them if you kill off the railroads by political baiting.

Harriman Awards for Accident Prevention

For the second consecutive year the Union Pacific System has been awarded the E. H. Harriman Gold Medal for the most conspicuous accident prevention work in America during the last year, it is announced today by Arthur Williams, president of the American Museum of Safety. The award was made on the basis of records submitted to the Interstate Commerce Commission showing that not a single passenger was killed on this railroad system during 1925, though it operated more than 53,000,000 locomotive miles and more than a billion passenger miles: that only 5 employes were killed in non-train accidents, including shop accidents of all kinds, and only 407 employes were injured in such accidents during 105,000,000 man-hours of work during 1925; and that in train and train service accidents only 24 employes were killed in 53,000,000 locomotive miles of operation.

The silver replica of the Harriman Medal was awarded to the Duluth, Missabe and Northern Railroads as having done the best safety work of the year among roads operating between 1,000,000 and 10,000,000 locomotive miles and the bronze replica of the Harriman Medal was awarded to the Green Bay and Western Railroad as the most conspicuous example of successful accident prevention work among roads operating under one million locomotive miles during the same year.

In announcing these decisions Mr. Williams said: "The statistics examined by the Committee of Awards show a remarkable record of accident prevention on practically all of the railroads of America.

"A study of Interstate Commerce Commission records shows for the period of 1907 to 1924 inclusive, a reduction of 81 per cent in the total number of casualties resulting from collisions on steam railroads with an accumulative saving of 87,000 casualties: including the year 1925 these statistics show that in 18 years more than 95,000 casualties —that is, deaths and serious injuries—were averted as a result of the organized accident prevention work of American railroads. In addition to this saving of life and limb it is apparent from recent authoritative statistics that during the last 4 years there has been a financial saving of more than $116,000,000 to the railroads of the country as a result of this reduction of accidents.

"It was brought out at the meeting of the committee of award that in the case of the Duluth, Missabe and Northern Railroad not a single passenger or employe had been killed in either train or train service accidents during 1925, despite an exposure of 1,830,000 locomotive miles and 6,000,000 man-hours of work in its shops.

"This railroad has operated during the last 3 years without a single death and without the loss of an arm, hand, eye, leg or foot to any employe or passenger—a truly remarkable record. One of the car repair shops of this road, where approximately 2,000 cars are repaired a month, has not had an injury causing the loss of even one day's time in more than 8 years: this despite the fact that the road moved more than 21,000,000 tons of iron ore and other freight during the last year and employed an average of 2,700 men during the year."

Medals are offered annually by Mrs. E. H. Harriman.

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The Use of Freight Cars

Elsewhere in this issue there appears a paper presented to the Railroad Section of the A. S. M. E. by L. K. Sillcox, Gen. Supt. of Motive Power of the Chicago, Milwaukee & St. Paul that is not only timely, but a very important one in that it presents some new angles of one of our greatest railway problems, "The Use of the Freight Car." To many the term "freight car" as subjects pertaining thereto are trivial, but for those that do not fully appreciate the importance or magnitude that the freight cars play in the national life, a study of the fundamental feature given in the following table will indicate the value of solution of problems in relation to the use of freight cars.

Railways as a Factor in Our National Life

Total investment in our railways about	$25,000,000,000
Income from operation (1925)	$ 6,239,353,447
Income from freight (1925)	$ 4,596,952,895
Average freight income per day	$ 12,594,336
Average of freight income per hour	$ 524,764
Total number of freight cars	2,407,000
Total number of freight cars (less work and repairs 275,000)	2,132,000
Average earning per car per year	$ 2,156
Cost of repairs, about	$ 385,000,000
Average per unit, about	$ 160,000
Security holders in our railways, about	2,000,000
Held by Banks and Insurance Co.s, about	$ 3,000,000,000
Citizens either served, or affected by and should be interested in this problem, about	117,000,000

Mr. Sillcox has given examples that clearly indicate that depreciation and retirement factors are important features of operating economy. The following table gives the practice in respect to this matter on fifteen of our leading railways. A greater uniformity or standardization of depreciation charges would add to the reliability of monthly and annual reports of operation:

Rates of Depreciation. Per Cent

Railway Company	Locomotives Per cent	Pass. Cars Per cent	Freight Cars Per cent	Work Equipment Per cent
One	4.5	4.5	4.5	4.5
Two	3	2	3	2
Three	3	3	4	5
Four	2.5	2.5	3	2.5
Five	2	2	2	2
Six	4.5	2.5	5	5
Seven	3	3	4	4
Eight	2	1.5	2	2
Nine	2.5	2.5	2.5	2.5
Ten	3.5	3.5	4	4
Eleven	4	4	4	4
Twelve	4	4	4	4
Thirteen	3	3	3	4
Fourteen	2	2	2.75	2.75
Fifteen	3.44	3.73	3.31	4.75
Average	3.13	2.88	3.54	3.4

From the foregoing it will be seen that on fifteen of the largest railway systems in this country the theoretic life of equipment is as follows: Locomotives from 22 to 50 years. Passenger cars from 22 to 66 years. Freight cars 22 to 50 years, and work equipment from 20 to 50 years.

The Transportation Act of 1920 directed the Interstate Commerce Commission to fix uniform rates of equipment depreciation to be used by all carriers, and investigations were at once begun to determine a fair set of rates.

During Federal Control the Director General issued an order in May, 1919, that all carriers during the period of control to depreciate equipment placed in service after December 31st, 1917, at 4½ per cent.

Quite a number of lines have continued to use this rate since the termination of Federal Control, and to that extent depreciation charges are made more uniform or comparable now than in pre-war years.

"Depreciation Charges" with respect to any equipment shall cease when the difference between the ledger value and the estimated scrap value shall have been credited to the accrued depreciation account.

With the foregoing facts in mind it is not difficult to understand why there is such a wide range of difference in the apparent operating efficiency of two lines, fairly comparable throughout, except as to the amount of depreciation charges taken up and charged to operating expenses each month.

This one feature alone has much to do with affecting the integrity of operating statistics, particularly when used for comparative purposes, as in considering values.

It may be said that on lines other than those shown in the tabulations fluctuations have ranged from 1 to 6 per cent and until the Commission shall specify an exact rate to be charged on account of depreciation of equipment, desired results will not be attained.

A Neglected Factor

During the past few years wonderful strides have been made by our railways in the direction of greatly increased efficiency in operation, and a marked change in their re-

lations with the public, and while these two features combined have resulted in a wonderful improvement there are yet many directions in which still greater improvement can be made, and in one of these is the *use* and *abuse* of freight cars both by their owners, users and the shippers.

As a result of the splendid work of the A.R.A. and other public relations bodies, also the great help rendered by railway officers and employees. There has been almost a reversal of former antagonistic feeling toward our railways, so that today the public in general, and the shipper in particular, not only concedes the railways have some rights, but are disposed to give them a reasonably fair deal in most all matters except the use of freight cars. There are thousands of shippers who have for many years been using loaded freight cars consigned to them as auxiliaries to their warehouses or for storage purposes. A majority of these offenders have no intention whatever of providing themselves with proper terminal or warehouse facilities or to promptly make empty and return to service cars consigned to them under load. Thousands of these people actually do a retail business, not from their store or warehouse, but from a freight car which is not their property, and which they should not be allowed to either use in this manner, or hold under load longer than it can be made empty with proper facilities.

In the absence of any accurate check as to the extent of this evil, it has been estimated that from 150,000 to 200,000 freight cars are thus either being used for purposes other than intended, or held under full load awaiting change in market price of some commodity or other reason entirely foreign to transportation, when other shippers badly need cars of this kind or class.

We particularly direct our readers attention to the conclusions in Mr. Sillcox's paper as they contain excellent suggestions combined with good business logic and their adoption would result in great improvement in the freight car situation in general.

We cannot help but stress what, in our opinion, is paramount to all others at this time and that is with respect to the *misuse* and *abuse* of freight cars which are part of the physical property of railways. They belong to the stockholder whose official representatives should see that all physical property intended for and essential to proper transportation should be used for that purpose only and not diverted to other uses, such as the pernicious, expensive, and unnecessary custom of allowing a great number of cars to be regularly used as auxiliaries to stores or warehouses, etc., when they should be promptly made empty and returned to transportation service.

High Locomotive Boiler Pressures

We have commented at various times in the past upon the fact that the tendency exists to raise the steam pressure carried by the locomotive boilers with a view of increasing efficiency of the engine. A short time ago an engine was placed in service by a road in the east in which the boiler carried a pressure of 350 lb. per square inch, which after a test prove to be successful, and now the same road is completing one with 400 lb. pressure per square inch.

Tests are also being made in Germany with an ultra high pressure three cylinder compound locomotive of the 4-6-0 type which was built by Henschel & Sohn, Cassel, Germany, for the German State Railways.

Steam at three different pressures is produced in this locomotive at approximately 200, 850 and 1100 lb. per square inch. The 200, and 850 lb. pressures only are employed in the engine cylinders. The 1100 lb. steam is used in producing the 850 lb. steam.

The method of producing this high pressure steam is brought about by unusual characteristics, the firebox is a small subsidiary boiler into which the water is forced by a pump and steam raised at the above pressure. They have designed the engine with the idea to testing the practical potentialities of what has long been known to represent theoretically a most desirable feature, that of employing high pressure steam in combination with two stage expansion and superheat. The engine has two outside low pressure cylinders and one high pressure cylinder located between the frames.

The exhaust from this high pressure cylinder is mixed with highly superheated steam generated in the cylindrical part of the boiler, and after this passes to the low pressure cylinders, so that after doing its work in the high pressure cylinder it is subjected to treatment with its characteristics before it passes to the low-pressure cylinders for further expansion and final exhaust.

The 850 lb. stem per square inch is produced by passing the feed-water over heating coils containing steam at a pressure of from 1,100 to 1,300 lb. per square inch. These coils, mounted in the high pressure boiler, receive their steam from the tubes which make up the water-tube firebox of the locomotive. The firebox water tubes and the heating coils constitute a closed circulating system, by this arrangement much of the difficulty which arises from boiler scale is avoided.

The tests were made during the past few months and as yet the results are not available. It is expected according to reports to save about 25 per cent in fuel as compared with standard locomotives, and to develop about 40 per cent more power. We hope to be able to give further details of the construction in a subsequent issue.

Railway Performance in 1926

The transportation needs of the country have been accomplished by the railroads during the past year. Not only have they successfully carried the greatest freight traffic in their history but they have done so without any difficulties. They have also at the same time improved the condition of their rolling stock.

In order to provide for this so as to meet the growing requirement of transportation of the country, enormous expenditures exceeding those for any previous year have been made.

The railroads had more surplus freight cars in good repair and immediately available for service if necessary while there was no car shortage reported. Despite the fact that loading of revenue freight by far exceeded previous years, there has been a supply of surplus freight cars throughout the summer and fall. There was also a substantial improvement in the condition of railway equipment as the end of the year approaches, reports showing a few freight cars were in need of repair. This shows that the railroads were not only able to keep pace with the current repairs despite the fact that the traffic was the greatest, while at the same time they were able to bring about a reduction in the number of cars in need of shopping, a small percentage were in need of heavy repair. Locomotives in need of repair also showed a substantial decrease.

The railways of the country will enter upon the new year with the prospect of favorable gross earnings and well equipped to handle their business, and they will be able to render a satisfactory service to the public.

There is no real railroad problem to day so far as service is concerned, and with a continued increase in business during 1927 which everyone has reason to expect will come the railroads will continue in the future as they have

in past, to meet their service obligations unless there is interference with their present efficient operation, or a failure to recognize an adequate basis of earning and credit. If given fair treatment at the hands of the public, they can be counted upon to continue their progress and their service to the nation.

Progress in the Use of Light Signals

Light signals are being substituted for semaphores and other means of giving signal indications as fast as replacements are necessary on the railroads of this country, according to report just received from the principal railroads of the United States by the Signal Section of the American Railway Association.

The reports have been submitted to the Signal Section in connection with a study which that body is making as to what modifications can be made in signal methods now used by the railroads in order to increase safety both to passengers and employes and to enable the railroads to handle the constantly increasing traffic.

Light signals have the following advantages over other kinds of signal indications:

They are more discernible at all times and at a greater distance and are less confusing.

They are more economical to operate.,

There are three principal types of light signals now being installed. One involves the use of white lights exclusively, the lights being arranged so as to reproduce semaphore indications. Another type uses red, yellow and green lights which are arranged in a manner similar to the white lights. The third type also uses red, yellow and green lights but they are operated singly in a manner similar to the systems now used in many cities for the regulation of street traffic.

In changing to light signals the railroads are endeavoring to simplify the present system of signal indication so as to assist in bringing about a more prompt interpretation of the indications displayed.

The railroads realize that the capacity of their tracks can be regulated by the use made of signal devices. Many of them are shortening the length of "blocks" in automatic block signal territory, that is, they are placing their signals closer together than formerly, and at each "block" there is a signal that gives an indication not only as to two preceding "blocks."

Practice shows that under this system, trains kept running, even though at reduced speed, are advancing more rapidly relatively than by running them at higher speeds and keeping them more widely separated. This enables a railroad to move a heavier freight tonnage over its tracks in less time and expedites the movement of freight to the advantage of the shipper. It also enables the railroads to obtain greater service out of their present trackage facilities, thus substantially lessening the necessity for capital expenditures for additional tracks. This means a saving to the public and results in greater efficiency in operation.

Investigation of Motor Truck Operation

During the recent investigation of motor bus and truck operations by the Interstate Commerce Commission, the Association of Railway Executives appointed C. S. Duncan, economist of the organization, to attend all meetings and report developments. In his report, which he has just completed, Mr. Duncan discusses the motor truck in part, as follows:

There can be little doubt from the evidence given that a very considerable part of the motor truck operation today is supplementary to rail service. This is true of all operations that have taken the place of the horse-drawn truck or wagon in getting commodities to the freight station and in carrying commodities from the freight station. On the other hand, there can be as little doubt that the increase in the amount of the motor truck traffic over and above the original horse-drawn truck or wagon traffic and the increased range and speed of motor truck operation have made the motor truck more of a competitor with rail lines than the earlier operation.

The 2,500,000 motor trucks in operation today have an average hauling capacity of about one and one-fourth tons per unit, which makes a total of carrying capacity of about 3,125,000 tons. This total number of transportation units, with this substantial total carrying capacity, is operating day and night throughout the country, partly in competition with and partly supplementary to rail service.

Both the motor truck operators and the shippers by motor truck who testified before the Commission took the position that motor truck operations were not really competitive with those of the steam carriers, but that the motor truck operated in the field of the short haul where the railroads claimed their traffic was not remunerative and served as extensions and supplementary service to the steam carriers, thus becoming feeders to the steam lines. The facts as developed showed that there are considerable operations by motor truck that cover the complete transportation from origin to point of consumption for certain types of commodities and in certain localities. It was also developed that the motor trucks, like the buses, operate over the improved highways which more often than not parallel the steam lines.

No one made any claim, as has been said, that motor trucks can now supplant rail lines as the essential and fundamental transportation facilities upon which the movement of the country's traffic must go. On the other hand, a real and immediate problem arises with regard to certain short haul and branch line railroads. Truck operations may now be threatening the very existence of such rail lines. Both operations may not be essential to the communities which they serve. Certainly it is a question for those communities to determine which type of transportation they will have.

The large question is that, if the motor truck has become a permanent part of our national transportation system, how can the two different types of transportation facilities work together in such a way that the fundamenal transportation system shall not be injured or destroyed?

New Russian Brake Fails

Experiments intended to demonstrate the efficiency of the new Kazantev brake, which Russians hoped would replace the standard type of brake used in this country ended disastrously on November 16 when a train of 36 cars equipped with the Kazantev brake toppled over an embankment near Tiflis, Georgian Republic. The train was going at full speed and seven persons were killed and more than a score were injured when the braking apparatus failed to function.

Mechanical Division A. R. A.

The American Railway Association's mechanical division general committee met in New York City, November 18th, and decided to hold the annual meeting at Montreal, June 7 to 9, inclusive, 1927, with no exhibitions of railway appliance or machinery. The invitation to hold the meeting in Montreal came from the Canadian National and Canadian Pacific Railways.

The Use of High Steam Pressure in Locomotives*

A Summary of the Advantages and Review of the Applications of Pressures Above 240 lb. Per Sq. In.

By Edward C. Schmidt and John M. Snodgrass

In the older current locomotives the working pressure lies generally between 180 and 210 lb. gage, in those of recent construction it varies from 200 to 250 lb. The last mentioned pressure is still unusual, and of the 70,000 locomotives in service in the United States, fewer than a thousand carry this pressure, which is the present maximum in locomotive boilers of standard design and the practice abroad has not differed much from our own in this respect.

In the use of high pressures, locomotive practice has lagged behind that in stationary plants chiefly because of the difficulty of adapting the water-tube boiler to locomotive conditions. Within the last ten years the working pressure in central generating plants has been increased to about 600 lb. per sq. in.; and for special purposes, in small boilers of special design, the working pressure has been carried as high as 1,500 lb.

The firebox of the ordinary locomotive has extensive flat surfaces whose proper staying becomes more difficult as the working pressure is increased. While the maximum for which it is possible properly to stay the ordinary firebox is not yet definitely settled, it probably lies between 275 and 300 lb. In view of this fact and of the pressures in current use the term "high steam pressure" may be defined for the purposes of this presentation as a pressure of 300 lb. or more. However, since there are at present only two reciprocating locomotives using so high a pressure, certain facts are presented about those locomotives which operate at or near the usual current maximum pressure, namely, 250 lb.

Increasing the train load has always been, in American practice, the usual resort for attaining economy in general operation, and it has resulted in an unremitting demand for locomotives of greater capacity or tractive effort. For the locomotive designer an increase in steam pressure is an easy way to a moderate increase in capacity, and there has been a steady increase in boiler pressure from the earliest days of locomotive construction; the progress, however, has thus far been made by small steps of 10, 15, or 20 lb. at one time, and it has generally involved no radical departure in design. Interest in higher pressure is no new thing; what distinguishes our present interest in the subject is that the contemplated pressure increases far exceed our previous changes—the pressure used in the American locomotive is 100 and 150 lb. in excess of the current maximum, and in the case of the high-pressure locomotive of the German State Railways the excess is 600 lb.

Twenty-five years ago there was considerable discussion of this subject, although it was then conceived in terms rather different from those in which we view it today. Under the demand for increased capacity the locomotive designer was confronted with the question as to whether to get this increase by using higher pressure or by applying a larger boiler and using steam of the then current pressure in larger cylinders. The common pressures of the time were 180 and 200 lb.; 250 lb. was then considerably in advance of any existing practice. Dr. W. F. M. Goss, in 1904 and 1905, undertook experiments to try to settle this question. He measured the performance of a locomotive using saturated steam in single-expansion cylinders, operated under boiler pressures of 120, 160, 180, 200 and 240 lb. per sq. in.

These tests defined the direct gains due to higher pressure, and also the evaporation per pound of coal under different rates of combustion and of evaporation. He then calculated the increased heating surface which might be obtained if the increase in boiler weight required by the higher pressure were used instead to produce a boiler of ampler heating surface which would operate under the lower pressure and by virtue of its great heating surface under a more economical rate of combustion. The results indicated that for pressures of 180 lb. and above the gain due to increased pressure would be nearly or quite offset by the gain in evaporative efficiency obtainable from the larger boiler of like weight. After making due allowance for the increased difficulty and cost of maintenance at the higher pressure, Dr. Goss concluded that for the pressures under consideration and for saturated steam in simple cylinders there was no substantial overall economy in using pressures in excess of 180 or 200 lb. His chief conclusions were: "Assuming 180 lb. pressure to have been accepted as standard, and assuming the maintenance to be of the highest order, it will be found good practice to utilize any allowable increase in weight by providing a larger boiler rather than by providing a stronger boiler to permit higher pressures."—and "A simple locomotive using saturated steam will render good and efficient service when the running pressure is as low as 160 lb.; under most favorable conditions, no argument is to be found in the economic performance of the engine which can justify the use of pressures greater than 200 lb." In comparing these conclusions with the views held today it must be borne in mind that the design of recent locomotives has encroached much further upon the available space and weight limits than did the locomotive of two decades ago, that we are now using superheated steam, and that never before in the history of the railroads has the necessity for the greatest economy in steam and coal been so urgent.

The interest in high boiler pressure persisted, however, notwithstanding Dr. Goss's conclusions, because at the time, the demand for increased capacity overshadowed considerations of economy. The situation in America was presently greatly relieved by the introduction of superheated steam which, although it had been for some years in use on European roads, was first extensively applied here to locomotives on the Canadian Pacific Railway about 1905. The great gain in capacity and economy resulting from its use far exceeded anything to be hoped for from such increases in steam pressure as were then under consideration, and proposals in general pressure increases were temporarily dropped.

The Advantages to Be Derived from High Pressure

The reasons for considering higher pressure in locomotive service and the advantages to be derived from its use may be stated as follows: (1) The use of higher steam pressure results in a considerable decrease in steam consumption, and a corresponding—though slightly smaller—decrease in coal consumption. (2) Within the usual fixed limits of width and height the locomotive designer may obtain greater tractive force and greater power by increasing the boiler pressure. It is fortunately possible to obtain simultaneously both these benefits; and it is not

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necessary, as in some locomotive-economy-promoting devices, to trade economy for capacity or vice versa.

If the new high-pressure type of boiler proves ultimately to be inherently lighter than the present standard boiler, then, for a given total engine weight, it will be possible to obtain greater tractive force with high steam pressure; but we cannot know whether this will be true until the new type of boiler has been further developed and perfected.

The magnitude of the gains to be derived from high pressure is illustrated by the Rankine-cycle efficiencies shown in Table 1:

TABLE 1—SHOWING RANKINE-CYCLE EFFICIENCIES FOR SINGLE EXPANSION CYLINDERS, USING STEAM AT VARIOUS INITIAL PRESSURES, SUPERHEAT OF 250 DEG., AND EXHAUSTING AGAINST 20 LB. ABSOLUTE BACK PRESSURE

	Temperatures				
Initial steam pressure lb. per sq. in. gage	Of the saturated steam deg Fahr.	Of the superheated steam deg. Fahr.	Rankine-cycle efficiency per cent	Gain in efficiency over that attained with 200 lb. initial pressure per cent	Increment of gain, per cent
200	388.0	638.0	18.90	....	...
250	406.2	656.2	20.34	7.61	7.61
300	421.9	671.9	21.50	13.75	6.14
350	435.9	685.9	22.49	19.00	5.25
400	448.4	698.4	23.38	23.70	4.70
500	470.2	720.2	24.81	31.28	7.58
600	489.1	739.1	25.98	37.46	6.18
700	505.7	755.7	26.95	42.59	5.13
800	520.6	770.6	27.76	46.88	4.29
900	534.2	784.2	28.47	50.63	3.75

for pressures varying from 200 to 900 lb., at 250 deg. superheat, and an absolute back pressure of 20 lb. per sq. in. The fifth column shows the gains in efficiency expressed as percentages of that attained at 200 lb. pressure; it will be noted that 400-lb. steam gives 23.70 per cent greater efficiency than 200-lb. steam, and 800-lb. steam gives 46.88 per cent more than 200-lb. In view of the difficulties of utilizing extremely high pressure on locomotives, it is significant to observe that the increment of gain decreases as the pressure is increased. As indicated in the last column of Table 1, the efficiency to be gained by raising the steam pressure from 200 to 300 lb., for example, is 13.75 per cent; whereas the gain by increasing the pressure from 800 to 900 lb. is only 3.75 per cent; in other words, while the total gain in efficiency secured by increasing the pressure from 200 lb. to 900 lb. is over 50 per cent, the first 100-lb. stage of the increase gives more than 3½ times as much benefit as does the last 100-lb. stage.

In reciprocating non-condensing engines operating with moderate pressure and under excellent conditions, the actual efficiency has proved to be from six-tenths to seven-tenths of the ideal efficiency shown in Table 1. The proportion varies, depending on whether the engine is operated simple or compound, and upon the amount of superheat. There will probably be no very radical modification of this proportion with the use of higher pressure, and we are warranted in expecting that the relation between the actual efficiencies at various pressures will not differ greatly from the relation between the theoretical efficiencies shown in the table. Such considerations make it certain that the gains attainable by the use of high pressures are very considerable and well worth striving for.

As has already been pointed out, the second advantage, namely, the increase in tractive force attainable with high pressures, has always been of great importance and it has become more and more so as locomotive design has approached closer to the weight limits and to the space limits set by the track clearance, which have been nearly or quite reached in many instances. Anything which under these conditions will permit the designer to continue to produce a more powerful machine which will draw a heavier train is bound to be regarded as of the utmost importance by every railroad operating officer, for it opens again the avenue to highest operating efficiency and economy.

Both advantages are important, and which one is regarded as the more so will depend upon the circumstances. Probably in European practice, with their light train load and high fuel cost, the gain in economy will seem more important than the gain in power; although present fuel costs on American roads have mounted to a point where our attitude toward such an engineering problem must be quite different from what it might properly have been ten years ago.

These two advantages of high steam pressure have been variously stated and explained and it may be of interest to quote some of these statements. In an article on Future Possibilities of Locomotive Design, Louis H. Rehfuss says, for example:

"The whole reason for this trend toward high pressures lies in the fact that while the total heat to be imparted to a pound of water remains practically the same at all pressures, the heat of vaporization, which is never available as mechanical energy, steadily decreases as the pressure increases. This means that as the pressure rises, a steadily increasing percentage of the heat is available as useful work. Theoretical savings, of course, are larger than the practical, because of the greater condensation occurring at the higer temperatures, and of other factors. . . . . The necessity for high steam capacity is obviated by the use of high pressures. Thus a pound of saturated steam at 500 lb. pressure occupies but a 0.90 cu. ft. contrasted with the 2.14 cu. ft. occupied by saturated steam at our customary 200-lb. pressure. When the increased power available in the higher-pressure steam is also taken into consideration, it will be seen that the steam capacity with 500 lb. pressure need be but a third of that used with the 200 lb. pressure employed today."

Speaking at the exercises held on the Delaware & Hudson Railroad when the *Horatio Allen* was placed in service, John E. Muhlfeld, the designer of this engine, said:

"It was designed to determine what might be accomplished in the better production and utilization of fuel heat, by means of high steam pressure and the greater use of its expansive properties, in combination with the development of maximum hauling power in the most simplified form of a modern steam locomotive, consisting of two cylinders and four pairs of driving wheels. To illustrate, assume that to convert a certain amount of water into steam at 200 lb. pressure, 1199.2 lb. of coal must be used. To increase the 200 lb. pressure to 350 lb. only 7.4 lb. more coal must be used, and this increase of less than 0.62 per cent in fuel gives an increase of 150 lb., or 75 per cent in power. Then instead of using the steam of 350 lb. pressure, direct from the boiler in both the right and left cylinders and exhausting it out of the stack, it is used first in the right and again in the left cylinder, and by this double-expansion process the heat that has been put into the steam is more effectively utilized before it is exhausted to the atmosphere. By this combination it is calculated that the saving in fuel consumption per unit of work done by the locomotive when working in compound gear, as compared with the ordinary single-expansion cylinder locomotive, will be: First, the gain from increasing the steam pressure from 200 to 350 lb. will represent about 15 per cent less fuel consumed per draw-bar horsepower-hour. Second, the gain through double expansion of the steam will represent about 17 per cent less fuel consumed per drawbar horsepower-hour. Third, etc. . . . ."

On the other side of the account there are some difficulties in the design and operation of high-pressure locomotives which, while probably not insuperable ought nevertheless to receive due consideration. As has been intimated, the use of pressures above 300 lb. has entailed and will entail radical departure in boiler design. The experience with the Brotan boiler, having a firebox of

water tube construction, has, however, been extensive and encouraging. Similar types of construction have been used in *Horatio Allen* and in the high pressure locomotive built by Henschel & Sohn for the German State Railways. While the maintenance of such boilers, the maintenance of valves and piping, and lubrication under high temperature will introduce problems new to the railroad man there is in the results attained in high pressure stationary plants ground for the hope that these problems can be satisfactorily solved; and the experience of the New York, New Haven & Hartford Railroad with the McClellon boiler offers similar encouragement.

In the opinion of many railroad men, one of the most serious problems to be solved in adapting the high-pressure water-tube type boiler to American railroad conditions lies in the almost universal use of untreated boiler water on our railroads. Under the high temperature of the high pressure steam the scaling is sure to be serious, and the proper washing and cleaning of these boilers will interpose a serious objection to their widespread use. Such an objection is not, of course, insurmountable, but it will undoubtedly greatly retard the adoption of high pressure locomotives in many situations.

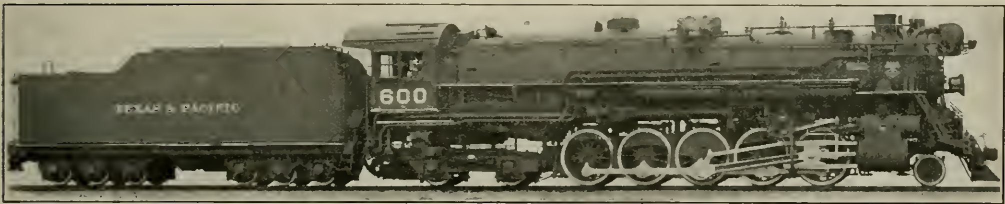
The maximum steam temperature which it is possible to carry without impairing the strength of the engine parts or without incurring unusual difficulties in lubrication remains to be determined. The maximum safe temperature is commonly held to be not over 750 deg. Fahr. although the basis for this opinion is not generally stated. Fortunately, the maximum steam temperature contemplated for locomotives does not greatly exceed this present limit. At 900 lb. pressure and 250 deg. superheat, for example the temperature of the steam is 781 deg. which is only 146 deg. more than the temperature of 200 lb. steam with the same superheat (638 deg.). In high pressure stationary plants the steam temperature runs in the neighborhood of 700 deg. to 725 deg. It seems likely that the difficulties arising from such increases in temperature as are entailed by the use of steam of even 900 lb. pressure can ultimately be overcome.

High Pressure Locomotives in Service or Under Construction

As previously stated, in view of the very small number of locomotives actually in service using high pressure as above defined, it has seemed useful to list here not only those using pressures in excess of 300 lb. but also those operating at or near the current maximum pressure.

Since 1916 the Pennsylvania Railroad has placed in service over 500 locomotives operating at a steam pressure of 250 lb. These are engines of the 2-10-0 type used in work which require them to maintain great tractive effort over protracted periods, they were consequently, for economy sake, designed with limited cut-off; that is their valve gear is so designed that no cut-off in excess of 50 percent of the stroke may be attained, and the cylinders are proportioned with respect to the limited cut-off and the high pressure. When these locomotives were originated 250 lb. was considerably in advance of usual pressures, and this pressure was adopted chiefly because of the limited cut-off. This use of moderately high pressure to attain cylinder economy by means of more favorable expansion ratios is one which has recently attracted much attention and gained much favor. The boilers of these Pennsylvania locomotives are of the usual extended wagon-top type with Belpaire fireboxes; the barrel plates are $1\frac{1}{4}$ inch thick and the boilers are otherwise strengthened for the high pressure; but they embody no other important departures from ordinary boiler design. Their superheat varies up to 280 deg.

About a year and a half ago the Lima Locomotive Works completed an experimental locomotive of the 2-8-4 type called the A-1 which embodied various novel features of design. It is interesting in this connection however, chiefly because it carries 240 lb. boiler pressure and has its cut-off limited to 60 percent. There are no unusual features in the boiler design—at least none which were demanded by the high pressure. This engine was first placed in service on the Boston & Albany Railroad, and afterward used on various roads. The Lima Works has since built 25 similar locomotives for the Boston & Albany Railroad which carry the same pressure and is now building 20 additional engines for this road. During the present year the Texas & Pacific Railroad has placed in service 10 similar locomotives of the 2-10-4 type, which have boilers of the usual design carrying 250 lb. pressure. The Lima Works is also building for the Illinois Central Railroad 50 locomotives like the A-1 of the 2-8-4 type carrying 240 lb. boiler pressure; and for the Pennsylvania Railroad it has under construction 25 locomotives of the 4-8-2 type which will carry 250 lb.



2-10-4 Type Locomotive of the Texas & Pacific Railway Built by Lima Locomotive Works, Inc.

The highest pressure in a locomotive boiler of ordinary design of which we have knowledge is 285 lb. This pressure is carried on an experimental turbine driven locomotive built by Beyer, Peacock & Company in England. It weighs 143 tons and develops 2000 hp. The boiler is of the usual locomotive type with Belpaire firebox, steel firebox sheets, and steel tubes.

The first locomotive boiler with a water-tube firebox was applied to a freight engine on the Austrian State Railway in 1901. It was designed by the chief engineer of the railway, Herr Brotan, and it is obviously the forerunner of the McClellon boiler, the boiler of the Horatio Allen, and that used on the high-pressure locomotive of the German Railways.

Until 1885 the maximum boiler pressure in use on the Austrian Railway was 150 lb., but at about that date they began to use higher pressure. Under 150 lb. boiler pressure the life of the copper firebox sheets was about 25 years, but as the pressure was gradually increased up to 240 lb. the life of these sheets became shorter until finally they had to be renewed every three or four years. These maintenance difficulties were aggravated by the bad feedwater in use on certain parts of the system, and by the fact that some of the coal had a very high sulphur content, which caused rapid deterioration of the copper side sheets

and staybolt heads. This increase in the cost of maintenance appears to have been the chief reason for resorting to the water tube construction of the Brotan design, rather than any desire to use extremely high pressures. In the records available the Brotan boiler does not appear to have been used for pressures in excess of 240 lb.

In the Brotan boiler a hollow ring takes the place of the usual mud ring. This ring is connected at the front to the bottom of the main boiler shell; from the ring rise a number of small water tubes which form the walls of the firebox and which are connected at the top to a collecting drum of small diameter. In one design the collecting drum is connected into the rear tube sheet of the main boiler shell; in another design the drum extends forward above the main boiler shell and is connected thereto by several short vertical sleeves.

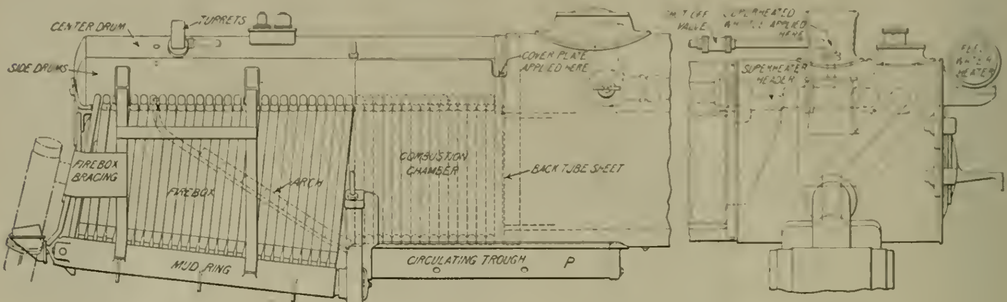
After the preliminary experience with the Boston boiler in 1901 it was applied to a considerable number of engines on the Austrian railways, and it was also tried on various other European railways, including those of Hungary, Russia, Switzerland, Prussia, and France. In recent years scores of locomotives with Brotan boilers have been placed in service on Austrian and Hungarian roads.

In 1916 the New York, New Haven & Hartford Railroad placed in service two Mikado-type locomotives with McClellon boilers carrying 180 lb. pressure. These boilers resemble in their design the Brotan boiler referred to above. Certain defects developed in these experimental locomotives and their removal and the development of the design was delayed by the death of the inventor, James M. McClellon. In 1920, however, these locomotives were modified in accordance with the experience previously gained and replaced in service. As a result of their satisfactory performance this railroad in 1924 placed the McClellon boiler on one of 10 Mountain-type locomotives ordered that year. More recently they have applied the same type of boiler on 10 additional new engines. All these engines, except the two first mentioned, carry a boiler pressure of 250 lb.

One of the illustrations shows the construction of this boiler on New York, New Haven & Hartford locomotive No. 3500, the Mountain-type locomotive which was placed in service in 1924. Between it and the standard boiler the chief differences are in the construction of the firebox and the combustion chamber. Except for a small section below the firedoor all flat plate surfaces are eliminated from the firebox, their place being taken by water tubes which are 4 in. in diameter at the sides, and 2 in. in diameter on the back head. The mud ring is formed by a single hollow steel casting from which the water tubes rise to three drums of small diameter which form the top of the firebox. These three drums are flattened where they adjoin and are kept in connection along the flattened surfaces by means of screw rivets. Steel braces running between the mud ring and the upper drums relieve the water tubes of all stresses except those which arise from the steam pressure. The firedoor opening is in a section of combined water-leg and water-tube contruction. The plate shown in this view forms a part of the bracing and it carries at the same time some of the back head and cab fitting.

The combustion-chamber walls are also formed of 4-in. water tubes which connect the three upper drums with a circulating trough located at the bottom of the chamber and extending forward under the main boiler shell. The purpose of this circulating trough is to permit the circulation of water from the main boiler barrel to the firebox and the combustion chamber. It is riveted on the outside of the rear course of the main shell at the bottom; its front end extends ahead of the tube sheet and opens into the boiler through the shell, while the rear end is riveted to a flanged opening in the forward throat sheet.

The circulation in this boiler has proved to be excellent and the time required to fire it up is about two-thirds of the time usually required with the standard boiler. It



Details of the McClellon Water Tube Boiler

Back View of McClellon Water Tube Boiler

can also be washed out in considerably less time than is required for the boiler of standard construction. Records kept since 1916 indicate that the cost of maintaining the McClellon boiler is roughly about one-half of the cost of maintenance of boilers of the usual type; and because of this great reduction in the amount of boiler work the locomotive has been more generally available for service.

As a result of their experience with the McClellon boiler, the motive-power officers of the New York, New Haven & Hartford Railroad are convinced of its suitability for use with high pressure, and of its economy of maintenance. As long as the water-tube firebox construction continues to be combined with standard construction of the main shell, the boiler pressure will, of course, continue to be limited by the design of the main boiler barrel, and this will probably not permit pressures much, if any, in excess of 300 lb. per sq. in.

After the ten Mountain-type locomotives above referred to were placed in service, extensive tests were made to compare the one equipped with the McClellon boiler (No. 3500) with one of the others of standard design (No. 3324). The two locomotives are substantially alike except as regards their boiler construction, steam pressure, and maximum cut-off. No. 3500 carries 250 lb. and has 70 per cent maximum cut-off, whereas No. 3324 carries 200 lb. pressure and has 80 per cent cut-off. The increase in maximum tractive effort of No. 3500 over No. 3324 amounted to 17.6 per cent. The steam per indicated horsepower hour for the two engines was, respectively 14.51 lb. and 15.52 lb., or a decrease of 6.5 per cent for locomotive No. 3500. The dry coal consumed per drawbar horsepower was 2.50 lb. for the locomotive of the new design and 2.95 lb. for the standard machine, which is a saving of 15.2 per cent in favor of the new type.

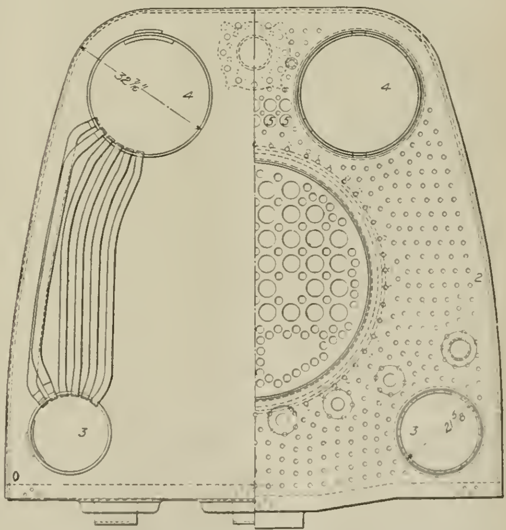
It is understood that the American Locomotive Company is now building for the New York, New Haven & Hartford Railroad, additional locomotives equipped with McClellon boilers which will carry a steam pressure of 265 lb. It is also understood that the Baldwin Locomotive Works is building a high-pressure locomotive equipped with McClellon boiler.

If we accept the definition of the term "high pressure" previously suggested, the only high-pressure locomotive now in service on any American railroad is the Delaware & Hudson Company's locomotive No. 1400 which was placed in service in 1924 and named the Horatio Allen. It carries 350 lb. boiler pressure. This locomotive was designed by John E. Muhlfeld, consulting engineer for the Delaware & Hudson Company, and was built by the American Locomotive Company. It is of the Consolidation type, has 298,000 lb. weight on the drivers, and, without the booster with which the tender is equipped, it has developed in service a tractive force of 95,000 lb. with the cylinders in simple gear at 4 miles per hour, and 75,000 lb. at 5 miles per hour when working compound. The engine has cross-compound cylinders which are respectively 23½-in. and 41-in. diameter, with a 30-in. stroke. The general design of the boiler of this locomotive is shown in the accompanying illustration. A full description of the Horatio Allen appeared in the January 1925 issue of RAILWAY & LOCOMOTIVE ENGINEERING.

Probably the outstanding difference in the proportions of the Horatio Allen as compared with locomotives of conventional design will be found in the distribution of the heating surface in the boiler. Out of a total heating surface of 3200 sq. ft., 1187 sq. ft., or 37 per cent, is located in the firebox. This is the result of the water-tube construction. . . . . Another factor of interest is the comparatively small amount of superheating surface, the total of which is 579 sq. ft. The purpose in this case, however, was to limit the maximum steam temperature to approximately 600 to 620 deg. Fahr., and this temperature became the controlling factor in the design rather than the amount of superheat. With a boiler pressure of 200 lb. per sq. in., the superheater starts to build up the temperature of the

High Pressure Boiler of the Locomotive "Horatio Allen"

steam from a saturated temperature of 388 deg. Fahr. With the pressure increased to 350 lb., however, the saturated-steam temperature is raised to approximately 436 deg. and the amount of heat which can be imparted to the steam within a limit of 620 deg. is correspondingly reduced. Until it is determined what effect will be produced by a combination of high pressures and high temperatures,



Half Sections Through Firebox Showing Circulating Tubes, Drums and Back Tubesheet of the Locomotive "Horatio Allen"

it was considered safer not to exceed the above maximum temperature.

When burning coal at the rate of 57.5 lb. per sq. ft. of grate per hour, this boiler has given an equivalent evaporation of 10.68 lb. of water per pound of coal and a combined efficiency of boiler and superheater of 75.8 per cent. The steam consumption of the main cylinders and the auxiliaries was 17.91 lb. per i.hp-hr. The dry coal used per drawbar horsepower-hour has proved to be 2.3 lb., which is equivalent to an overall efficiency of 8.02 per

cent; that is, the locomotive has delivered as work at the drawbar 8.02 per cent of the heat units in the coal fired.

As a result of the satisfactory performance of the Horatio Allen, the Delaware & Hudson Company is now building the John B. Jervis, a locomotive of similar design which will carry, however, a boiler pressure of 400 lb., or 50 lb. more than the former.

Dr. Wilhelm Schmidt, whose name is closely associated with the use of superheated steam, especially in locomotive practice, also carried on, over a period of several decades investigations in connection with high-pressure steam. The results of these investigations have received much attention during recent years, and it appears likely that there will be further important developments along the lines suggested by them. Dr. Schmidt's work, made largely in connection with stationary boilers and engines, leads to many important conclusions some of which are particularly pertinent to locomotive practice. The following is a single quotation from a translation of a paper by O. H. Hartmann of the Schmidt's sche Heissdampf-Gesellschaft:

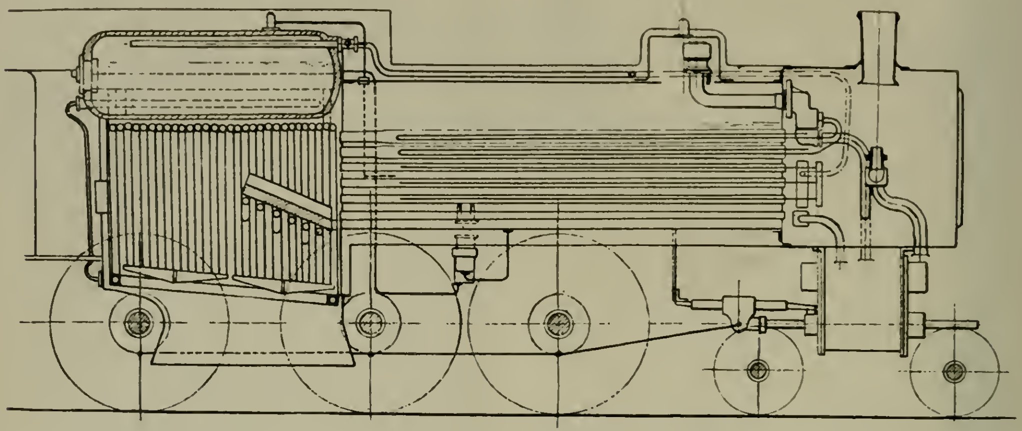
> The greatest advantages, however, are obtained by applying high-pressure steam to operate back-pressure reciprocating engines or back-pressure turbines, the exhaust steam of which is utilized. It is possible to obtain the same heat consumption per horsepower with a high-pressure exhaust engine working at 60 atmospheres initial pressure (852 lb.) and low back pressure as with a condensing engine working with the usual pressure, and all exhaust steam is still available for other purposes.

In the original paper presented before the Verein Deutscher Ingenieure, gives an extended account of the investigations made by Dr. Schmidt and his associates. Based on these investigations a locomotive which has been called an ultra-high-pressure locomotive was recently built for the German State Railways. This locomotive is a compound, three cylinder, 4-6-0, superheated-steam, high-speed engine, built by Henschel & Sohn, Cassel, Germany.

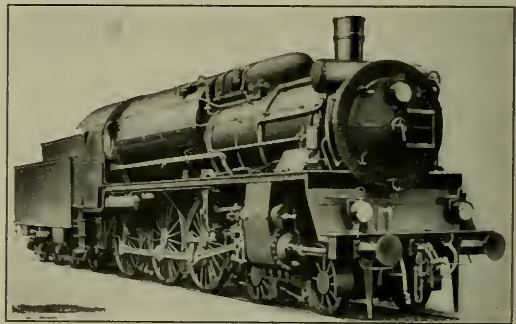
Steam at three different pressures is produced in this locomotive—at approximately 200, 850, and 1100 lb. per sq. in. The two lower pressures only are employed in the engine cylinders. The 1100-lb. steam is used in producing the 850-lb. steam. The single high-pressure cylinder of this locomotive receives steam at 850 lb. pressure from a special high-pressure boiler. The two low-pressure cylinders receive steam at approximately 200 lb. per sq. in. A fire-tube boiler of the usual construction produces 200-lb. steam which is mixed with the exhaust from the high-pressure cylinder to produce the steam supply for the low-pressure cylinders. Two superheaters, one for the 850-lb. steam, the other for the steam from the fire-tube boiler, are employed in order to permit the locomotive to take full advantage of superheating.

The method of producing the 850-lb. pressure steam in the high-pressure boiler has brought about an important feature in the design of the locomotive. The 850-lb. steam is produced by passing the feedwater over heating coils containing steam at a pressure of from 1100 to 1300 lb. per sq. in. These heating coils, mounted in the high-pressure boiler, receive their steam from the tubes which make up the water-tube firebox of the locomotive. The firebox water tubes and the heating coils constitute a closed circulating system. By means of this arrangement much of the difficulty which might arise from boiler scale is avoided. The accompanying diagrammatic sketch shows the arrangement of the principal elements of the German high pressure locomotive.

The locomotive was built for two working pressures, 853 lb. per sq. in. (60 kg. per sq. cm.) working pressure being carried in the back end, or high-pressure boiler, and 199 lb. per sq. in. (14 kg. per sq. cm.) in the barrel



Diagrammatic Sketch Showing Arrangement of the Principal Elements of the German High-Pressure Locomotive



High-Pressure Steam Locomotive of the German State Railways

of the normal or low-pressure boiler. The inner firebox is formed by water tubes the bottom ends of which reach into the water chambers of a hollow foundation ring, while their upper ends discharge into steam collectors. The system is filled with distilled water up to the tube ends in the steam collectors. From the latter, steam rises through vertical tubes to heating coils mounted in the high-pressure boiler, and the condensate falls back to the foundation-ring chamber through another set of tubes and there begins circulation anew. The heating of the high-pressure boiler is thus accomplished indirectly. The use of distilled water prevents the formation of scale in the firebox water tubes. The working pressure in the firebox tubes and the heating coils is 1100 to 1300 lb. per sq. in. (80 to 90 kg. per sq. cm.), and in the high-pressure boiler it amounts to 853 lb. per sq. in.

The low-pressure boiler, working at 199 lb. per sq. in., is of the standard fire-tube type. In order to reduce the formation of scale it has, besides the customary steam dome, a special feed dome with a grid over which the feedwater is sprayed. For the same reason the feedwater for the high-pressure boiler is pumped across from the main boiler barrel.

The steam at 850 lb. per sq. in. generated in the high-pressure boiler, after having undergone the superheating process in a small-tube superheater arranged in the lower flues of the fire-tube boiler, enters the steam chest of the high-pressure cylinder. The steam produced in the low-pressure boiler goes to another small-tube superheater located in the upper flues of this boiler. On its way from the superheater header to the two low-pressure cylinders the highly superheated low-pressure steam mixes with the exhaust steam from the high-pressure cylinder which at this point contains but a small amount of superheat. The resulting steam goes to the low-pressure cylinders at a temperature of about 570 deg. (300 deg. cent.); and after having performed its work in the cylinders, it is exhausted through the nozzle and smokestack in the usual way.

The low-pressure boiler is fed by a pump the delivery of which flows through a preheater; an injector of the current type is held in reserve. The high-pressure boiler gets its water supply from the low-pressure boiler by means of a pump, and there is also an injector for direct feeding of water from the tank to the high-pressure boiler.

Tests of this locomotive were to have been made during the past summer, but at the time this paper was prepared the results were not available. The designers expect it to save about 25 per cent in fuel as compared with standard locomotives; and, for like fuel consumption, to develop 35 to 40 per cent more work.

A brief description giving the principal dimensions of this ultra high-pressure locomotive of the German State Railways appeared in RAILWAY AND LOCOMOTIVE ENGINEERING for March, 1926.

Air Brake Tests at Purdue

A large number of railroad men from the United States and Canada visited Purdue University, Lafayette, Indiana, on November 12, to witness demonstration tests made on the freight train brake equipment of the Automatic Straight Air Brake Company. The equipment was designed to meet the tentative specifications for power brakes issued by the Interstate Commerce Commission, and are now on the rack undergoing tests. At the demonstration, held May 12th last, an opportunity was given those interested to see the standard K-2 equipment on the rack.

The investigations which have been going on for over a year and will, no doubt, be continued for another year or longer are being conducted by the American Railway Association for the purpose of obtaining more economical operation of trains and of promoting safety for the traveling public and railroad employees. The tests now being made are to determine which brake is the most economical, as well as the safest for stopping heavy freight trains.

This investigation is the most extensive that has ever been conducted in the history of power brakes for railway trains. Several new systems of brakes have been designed and constructed and are being subjected to these tests to determine if they are better adapted to railway service conditions than the brakes now in general use. These tests are being made in a special laboratory, fitted up by the American Railway Association. The rack provides for the entire air brake equipment of a large freight locomotive and 100 cars.

The schedule of rack tests for freight equipment which began in November, 1925, is as follows:

Series No. 1.—Run standard K triple valves with through schedule of tests in order to determine the exact functions of present standard brakes for a basis of comparison with the new brake system which will be tested.

Series No. 2.—Install heavier than standard graduation spring in all K triple valves and determine the effect of these springs upon the functioning of the K triple valves.

Series No. 3.—Run Automatic Straight Air Brake equipment through the schedule of tests.

Series No. 4.—Repeat schedule of tests for train of 100 cars with mixed equipments of standard K triple valves and Automatic Straight Air Brake equipments.

Series No. 5.—Run new Westinghouse equipments through the schedule of tests.

Series No. 6.—Repeat schedule of tests for a train of 100 cars with mixed equipments of standard K triple valves and new Westinghouse equipments.

Series No. 7.—If it is found advisable, after completing the six series of tests given above, repeat tests of Series No. 4 or No. 6 with mixed equipments of standard type K triple valves Automatic Straight Air Brake equipments and new Westinghouse equipments.

Series No. 8.—Install the three-position 10-20- duplex spring type retaining valves with which the pressure will blow down from a 10-inch cylinder with 8-inch piston travel, or a volume of 640 cu. inch., from 55 lb. to 25 lb. in 85 to 95 seconds when in high pressure position and will blow down from 45 lb. to 15 lb. in 45 to 55 seconds when in the low pressure position, and determine the effect of the blow-down time in the high pressure position on the cylinder pressure obtained with the standard type K triple valve.

The tests made on November 12 were typical of Series No. 3 now in progress, Nos. 1, 2 and 8 having been completed, and were made to give the visiting railroad men an opportunity to inspect the equipment and method of procedure used in conducting the investigation. The equipment now on test was submitted by the Automatic Straight Air Brake Company and was designed to meet the tentative specifications for power brakes issued by the Interstate Commerce Commission.

A schedule of informal tests was made for the general observation of the new equipment with respect to graduated release, maintenance of brake cylinder pressure, the ability to obtain emergency pressure at any time, and uniformity of brake cylinder pressure independent of piston travel, which are features claimed for the equipment.

In order to obtain accurate information concerning the functions of all the brake equipment tested and to be able to compare the data collected on standard type K equipments and the new types submitted a complete system of analyzing the data from observation and trainagraph has been installed.

The tests are being conducted under the direction of H. A. Johnson, director of research of the American Railway Association. He is being assisted by A. A. Potter, dean of engineering and director of the Engineering Experiment Station of Purdue University; G. A. Young, Prof. of Mechanical Engineering; Harry Ruebekoenig, Professor of Railway Engineering, and W. S. Helmer, who represents the A.R.A.

In addition there are a large staff of engineers who perform the tests and compile the data.

The Consolidation Type Locomotive in Britain

By Arthur Curran

The origin of the Consolidation type and the significance of its name have been explained, at various times, by J. Snowden Bell and others; and, hence, do not require further discussion at this time. The rather unusual employment to which this type has been assigned in England, however, adds an interesting chapter to its long and varied history, and affords a valid occasion for further comment.

For many years, "goods" trains in Britain were handled by engines of the 0-6-0 type. Coal trains, being heavier, were hauled by locomotives of the 0-8-0 type. Both of these types were, commonly, inside-connected. In due course, the 2-8-0 wheel arrangement was tried, though the English versions of this type were not, at first, very impressive from an American point of view.

It was not until 1903 that a real Consolidation appeared in England. In that year, the Great Western Railway built a 2-8-0 with 18½ x 30 inch cylinders, 55½ inch drivers, 225 lbs. of steam and 35,380 lbs. tractive power. This engine had piston valves and cylinder-saddle of the American style. The third pair of drivers was the main pair. The engines of this class ("28XX") were, and are, the most powerful on the road. Naturally, they get the heaviest express goods—i.e., fast freight—trains on the road. The class has been increased in numbers and improved in detail since the first one appeared.

There are now over a hundred 2-8-0 engines on the G. W. R., though this total may include some "odd" classes. In fact, it is of a subsequent class that American observers would be apt to speak, on account of certain features of its design and the service in which it was employed—experimentally, at least. English railways have done some unusual things, but this "takes the cake."

It was in May, 1919, that the first engine of the 4700 class appeared. The cylinders of this engine are 19 x 30 inches, drivers 68 inches in diameter, boiler 66 inches in diameter at front end and 72 inches at throat, working pressure 225 lbs., grate area 30.28 square feet, and tractive effort 30,460 lbs.

In the first place, this class embraces the only Consolidation type locomotives with driving wheels so large as 68 inches of which I have any record.

In the second place, No. 4700 was tried in passenger service, and is shown herewith on an up Bristol express. Curiously enough, the train is not so heavy as those commonly assigned to 4-6-0 engines on this run. Since the photograph was taken, nothing further has been heard of the experiment, and the engines of this class have, presumably, gone into fast freight service.

Due to the size of the drivers, the second pair is the main pair. The engines have superheaters and outside steam-pipes, and present a workmanlike appearance; but, for some reason, the class is not numerous.

The Consolidation type has, doubtless, found its way into passenger service in America at various times; but only in emergency or on mountain divisions. The attempt to use it in high speed service must be credited to the G. W. R., though it is not likely that this road really expected the experiment to be a success. It may have been thought that such a try-out would develop the merits or inherent faults of the type under the stress of speed, and thus aid in the acquirement of a knowledge of those factors which govern the design of a successful fast freight engine. In any case, the experiment is of sufficient interest to be worthy of some notice.

Unusual, also, is the application of the 2-8-0 wheel arrangement to a tank engine; yet there are 156 such on the G. W. R. With 19 x 30 inch cylinders, 55½ inch drivers and 200 lbs. working pressure, the tractive effort is 33,170 lbs. Though the drivers are of moderate diameter, the second pair is the main pair; this being due to the manner in which they are spaced.

Conditions on the short lines in the coal fields of Wales are such as to render useful a compact engine of considerable power and fair range of operation. The 2-8-0 tank engines have met these requirements hitherto;

Consolidation Type Locomotive in Passenger Service in England

though smaller locomotives, of the 0-6-2 type and inside connected, have been put in service recently.

The balance of the goods traffic is handled by Mogul engines, by 2-6-2 tank engines, and by those of the 0-6-0 type as have survived by reason of their adaptability to local or branch-line freight runs.

The vehicles used in freight service embrace a variety of designs, though the special types approximate more nearly American practice, due to the fact that they are mounted on four-wheel trucks. These special vehicles are designed for the conveyance of milk, timber and scenery, and measure 50 ft in length. Their capacity is something like 70,000 lbs.

Of the equipment having but four wheels in all, the "hopper ballast wagons" have a capacity of about 45,000 lbs., and the "open goods wagons" a capacity of about 32,000 lbs. In this connection, it must be explained that a great deal of the four-wheel equipment commonly used in Britain is—or was—the property of "traders"—i.e., shippers—and that the G. W. R. has repeatedly endeavored to interest its customers in the use of larger rolling-stock. The chief difficulty in the way of such a desirable plan is the existence of an elaborate system of docks and coal-handling plants which would have to be re-built if larger cars were used than those for which they were designed. Naturally enough, the owners of these facilities are opposed to a change which would cost them real money; and the railways are thus obliged to handle equipment which is, to say the least, out of date.

There is nothing out of date, however, about the manner in which the railways handle the equipment which is offered. Fast freight on the G. W. R. means a speed of 45 m.p.h. and delivery of goods in a specified time.

The size of the shipment makes no difference whatever, as the observer soon discovers! If the load is too much for any of the vehicles already described, the road plays its trump card by hauling into view a formidable-looking carriage consisting of steel girders mounted upon trucks capable of sustaining any load which the bridges will stand. A vehicle of this sort—there are several types of them—usually ends the argument forthwith, and the heavy shipment, whatever it is, is hustled away without further ceremony!

A great deal of the freight traffic is handled at night, as a result of which passengers do not see the big jobs which, to use a colloquialism, are frequently "pulled off." But in the "wee sma' hours" the heavy exhaust-beats of the Consolidations shatter the sable calm and announce to all and sundry that a nation's commerce is on its way!

In answer to a query, Mr. James J. Hill once remarked that the most inspiring sight, from his point of view, was a mighty freight engine battling the mountains in the service of Man! This beautiful tribute is a fitting conclusion to the foregoing brief comment on a type long famous in America, and, more recently, in Britain.

Notes on Domestic Railroads

Locomotives

The Baltimore and Ohio Railroad has ordered 20 Pacific type locomotives from the Baldwin Lcomotive Works.

The St. Louis & O'Fallon Railway has ordered one Prairie type locomotive from the Baldwin Locomotive Works.

The Pennsylvania Railroad has ordered 75 locomotives for passenger service from the Baldwin Locomotive Works.

The Hampton & Branchville Railroad has ordered one 4-6-0 type locomotive from the Baldwin Locomotive Works.

The Norfolk Southern Railroad has ordered 3 consolidatin type locomotives from the Baldwin Locomotive Works.

The Boston & Maine Railroad contemplates entering the market for 25 Mikado type locomotives.

The Montana, Wyoming & Southern Railroad has ordered one consolidation type locomotive from the Baldwin Locomotive Works.

The Chicago, Burlington & Quincy Railroad is inquiring for 12, 2-10-4 type locomotives.

The East Jersey Railroad and Terminal Company has ordered one six-wheel type switching locomotive from the Baldwin Locomotive Works.

The New York Central Railroad has ordered 70 locomotive tenders of 15,000 gal. capacity from the American Lccomotive Company.

The Seaboard Air Line Railway has ordered 25 six-wheel locomotives from the Baldwin Locomotive Works.

The Chicago, Rock Island & Pacific Railway is inquiring for 25 Mikado and 10 Mountain type locomotives.

The Montana, Wyoming & Southern Railroad has ordered one consolidation type locomotive from the Baldwin Locomotive Works.

The Atchison, Topeka & Santa Fe Railway has ordered 9, 4-8-4 type locomotives from the Baldwin Locomotive Works.

The Central of Brazil, has ordered 10, three-cylinders Pacific type locomotives and 3 Mikado type locomotives from the Baldwin Locomotive Works.

The Norfolk Southern Railroad has ordered 3 consolidation type locomotives from the Baldwin Locomotive Works.

The Louisiana & Arkansas Railway has ordered 2 Decapod type locomotives from the Baldwin Locomotive Works.

The Denver & Rio Grande Western Railroad is inquiring for 10 Mallet type locomotives.

The Atchison, Topeka & Santa Fe Railway has ordered 15 Mountain type locomotives, 15 Santa Fe type locomotives, 10 Pacific type locomotives and one 4-8-4 type locomotive from the Baldwin Locomotive Works.

The Western Maryland Railway has ordered 20 Decapod locomotives from the Baldwin Locomotive Works.

The Missouri Pacific Railroad is inquiring for 10 Mikado type locomotives, 26 eight-wheel switching tpe locomotives, 5 Pacific type and 5 Mountain type locomotives.

Passenger Cars

The Chicago & Northwestern Railway has ordered 3, combination passenger and baggage cars from the American Car & Foundry Company.

The Erie Railroad is inquiring for 21 steel underframes for passenger cars.

The Gulf, Mobile & Northern Railroad is inquiring for 2 coaches.

The Death Valley Railroad has ordered one combination passenger and baggage gasoline motor car from the J. G. Brill Company, Philadelphia, Pa.

The Chicago, Aurora & Elgin Railroad is inquiring for 15 motor cars.

The Union Pacific Railroad has ordered eight observation and 10 dining cars from the Pullman Car & Manufacturing Company.

The New York Central Railroad is inquiring for 27 all steel dining cars.

The Pennsylvania Railroad has sent out inquiries for 60 multiple unit cars.

The Chicago, South Shore & South Bend Railroad is inquiring for 10 motor cars and 10 trailers.

The Chicago & Northwestern Railway has ordered 8 baggage cars from the Pullman Car & Manufacturing Corporation.

The Norfolk & Western Railway is inquiring for 3, all steel dining cars.

The Atchison, Topeka & Santa Fe Railway is inquiring for 20 chair cars, 2 dining cars, 4 buffer library cars, 2 combination coach, baggage and smoking cars, 3 parlor cars, 2 business cars, 10 baggage cars, 10 postal cars and 5 combination mail and baggage cars.

The Union Pacific Railroad has ordered 10 baggage cars from the Standard Steel Car Company, 5 combination horse baggage and automobile cars from the Bethlehem Shipbuilding Corporation, and 2 baggage and mail cars from the American Car & Foundry Company.

The Chicago, Rock Island & Pacific Railway is inquiring for 5 dining cars, 10 coaches, 40 suburban cars, 4 combination baggage and smoking cars, 4 combination baggage and mail and 10 baggage cars.

The Missouri Pacific Railroad is inquiring for 70 passenger cars, including 10 chair cars, 16 coaches, 16 baggage, 7 dining cars, 8 combination baggage and mail, 3 Cafe club cars and 10 passenger and baggage cars.

Freight Cars

The New York Central Railroad has ordered 20 automatic steel dump cars, 50 tons capacity from the Magor Car Corporation.

The Great Northern Railway is inquiring for 25 all steel tank cars.

The Northern Pacific Railway is inquiring for 25 caboose cars underframes.

The Western Maryland Railway has ordered 500 hopper cars bodies of 50 tons capacity from the Bethlehem Steel Company.

The Conley Tank Car Company has ordered 100 tank cars of 8,000 gal. capacity and 100 of 10,000 gal. capacity from the American Car & Foundry Company.

The Norfolk & Western Railway is inquiring for 2,000 all steel hopper coal cars of 70 tons capacity and building 250 all-steel box cars in its shops at Roanoke, Va.

The Chicago & Northwestern Railway will build 500 freight cars in its own shops.

The Lehigh Valley Railroad is inquiring for 500 hopper cars of 70 tons capacity and 200 automobile cars of 50 tons capacity.

The Chicago, Rock Island & Pacific Railway is inquiring for 1,000 box cars of 40 tons capacity, 500 coal cars, 250 flat cars, 250 hopper cars and 500 automobile cars.

The Pacific Fruit Growers Express has ordered 600 underframes from the Pacific Car & Foundry Company.

The Long Island Railroad has ordered 5 caboose cars from the American Car & Foundry Company.

The Chicago & Northwestern Railway is inquiring for 250 ore cars of 70 tons capacity.

The Atlantic Coast Line Railway is inquiring for 100 ballast cars of 50 tons capacity.

The Winston Salem Southbound Railway is inquiring for 10 caboose cars.

The Northern Refrigerator Car Company, has ordered 201 refrigerator cars from the Pullman Car & Manufacturing Company.

The North American Car Company has ordered 300 tank cars from the Bethlehem Steel Company.

The Consolidated Rendering Company, has ordered one tank car of 6,000 gal. capacity from the General American Tank Car Company.

The Boston & Maine Railroad is inquiring for 500 hopper bottom coal cars.

The Norfolk & Western Railway is inquiring for 2,000 all steel hopper coal cars.

The Baltimore & Ohio Railroad is inquiring for 1,000 hopper cars of 70 tons capacity and 2,000 steel box cars of 50 tons capacity.

The Lehigh Valley Railroad is inquiring for 500 double sheathed box cars of 55 tons capacity.

The Fruit Growers Express is inquiring for 400 steel underframes.

The Chicago & Eastern Illinois Railway will rebuild 300 miscellaneous freight cars in its own shops.

The Jamaica Government Railways are inquiring through the car builders for 30 box cars.

The Atchison, Topeka & Santa Fe Railway is inquiring for 1,500 box cars and 300 gondola cars.

The Missouri Pacific Railroad is inquiring for 3,222 freight cars including 500, 40 ton box cars and 100, 50 ton gondola cars, 100 ballast cars, 20 caboose cars, 500, 50 ton box, 750, 40 ton automobile cars, 750 box cars of 50 ton capacity, 250 stock cars, 250, 50 ton hopper coal cars and 2 air dump cars.

Items of Personal Interest

D. S. Littlehales, master mechanic of the Northern Pacific Railway, with headquarters at Jamestown, N. D., has been transferred to Seattle, Wash., succeeding **J. W. Matheson**, who has been transferred to Glendive, Mont. **W. E. Dunkerly**, master mechanic, with headquarters at Glendive, has been transferred to Jamestown, N. D., succeeding D. S. Littlehales.

T. B. Koons, vice-president in charge of freight traffic of the Central Railroad of New Jersey, with headquarters at New York, N. Y., has retired.

H. T. Clark has been made road foreman of engines of the Baltimore and Ohio Railroad, with headquarters at Philadelphia, Pa., succeeding **J. E. Sentman**, transferred.

T. C. Carter has been appointed general foreman of the Illinois Central Railroad, with headquarters at Monroe, La.

Edwin R. Anthony has been promoted to superintendent of the Coast division of the Southern Pacific Railroad, with headquarters at San Francisco, Calif., succeeding **F. M. Worthington**; **J. J. Jordan** was appointed assistant superintendent of transportation.

R. E. Dougherty has been promoted to engineering assistant to the president of the New York Central Railroad, with duties covering the entire system. Mr. Dougherty headquarters will be at New York, N. Y.

Henry M. Lull has been appointed to the newly created position of assistant to the president of the Southern Pacific Railroad, with headquarters at Houston, Texas.

George E. Goodship, formerly assistant superintendent of the Detroit terminals of the Michigan Central Railroad, has been promoted to superintendent of the Detroit yards and the Toledo division, with headquarters at West Detroit, Mich.

A. A. Matthews has been appointed chief engineer of the Denver & Salt Lake Railroad, with headquarters at Denver, Colo., succeeding **R. D. Stewart**, assigned to other duties.

Eugene Fox has been elected vice-president of the Western Pacific Railroad in charge of traffic, with headquarters at San Francisco, Calif. Mr. Fox was formerly assistant traffic manager.

Reagh C. Boyden has been appointed mechanical superintendent of the Boston & Maine Transportation Company, with headquarters at East Cambridge, Mass., succeeding **C. C. King**, resigned.

F. W. Hillman, engineer of the Wisconsin division of the Chicago & Northwestern Railway, with headquarters at Chicago, has been assigned to other duties and has been replaced by **C. H. Perry**, formerly engineer of the Ashland division. **Dan C. Runseville**, assistant chief engineer, has retired under the pension rules of the company. **O. T. Hussemeier**, assistant engineer of the Green Bay division, has been promoted, to replace C. H. Perry.

L. C. Shults has been appointed master mechanic of the Southern Railway, with headquarters at Atlanta, Ga. **C. G. Goff** has been appointed master mechanic, with headquarters at Birmingham, Ala. **H. C. Trexler** has been appointed master mechanic, with headquarters at Somerset, Ky., **A. M. Lawton** has been appointed master mechanic, with headquarters at South Richmond, Va. **O. Small** has been appointed master mechanic, with headquarters at Alexandria, Va.

C. S. Koch has been made district supervisor of air brakes of the Missouri Pacific Railroad, with headquarters at Jefferson City, Mo.

Retirement of one official and promotions of three others on the Northern Pacific were announced today by **F. E. Williamson**, vice-president in charge of operations of that railroad. The changes are effective December 1.

C. L. Nichols, general manager, retires at the age of 70. He began his railroad service as a telegraph operator in 1870 for the C. B. & Q. In 1908 he entered the Northern Pacific service as superintendent at Livingston, and in November, 1909, was elevated to general superintendent. He became assistant general manager in June, 1919, and general manager in December, 1921.

T. H. Lantry, general superintendent at Livingston, will succeed Mr. Nichols as general manager. Mr. Lantry began his service as an operator for the Milwaukee Railroad in 1880. For twenty years he occupied positions in the operating departments of various lines. He began his service with the Northern Pacific as train dispatcher in December, 1900, at Spokane, Washington; he was promoted consistently and became division superintendent at Glendive, Montana, in August, 1911. In the World War he served as a Lieutenant Colonel with the U. S. Engineering Corps in Siberia from October, 1917, to January, 1920. He returned to the Northern Pacific as division superintendent at Livingston and was made general superintendent, with headquarters at that point in March, 1924.

Mr. Lantry's position as general superintendent of the Central district of the Northern Pacific is to be filled by promotion of **Thomas F. Lowry**, now superintendent of the St. Paul division, with headquarters in Minneapolis. He has been in the service of the Northern Pacific for 15 years.

G. H. Jacobus, now superintendent of the Montana division at Livingston, Montana, is to be transferred to Minneapolis, to succeed Mr. Lowry. Mr. Jacobus comes to Minneapolis after 20 years of service with the Northern Pacific, most of which was in Montana.

Fred Brastrup, superintendent of the Rocky Mountain division at Missoula, Montana, will succeed Mr. Jacobus at Livingston.

J. H. Johnson, now assistant superintendent at Staples, Minn., will succeed Mr. Brastrup at Missoula, Montana.

R. H. Denton has been appointed roundhouse foreman of the Missouri Pacific Railroad, with headquarters at Eugene, Ore.

R. N. Booker is made road foreman of engines, with headquarters at El Paso, Texas, succeeding **A. G. Newell**, and **A. C. Carter** is made assistant road foreman of engines, with headquarters at Tucson, Ariz.

P. Petri, division engineer, Cumberland division of the Baltimore & Ohio Railroad, has been promoted to engineer of maintenance of way, Eastern lines, succeeding **E. G. Lane**, transferred to the office of chief engineer maintenance as assistant chief engineer. **J. L. Maher**, division engineer, has been promoted to division engineer of the Connellville division, succeeding **A. R. Carver**. **George B. Farlow**, division engineer, Charleston division, promoted to division engineer Monongah division.

H. J. Force, chemist and engineer of tests of the Delaware, Lackawanna & Western Railroad, with headquarters at Scranton, Pa., having retired, **J. J. Laudig** has been appointed acting chemist and engineer of tests. **Gordon R. West** has been appointed engineer of reclamation of the Missouri Pacific Railroad, with headquarters at St. Louis, Mo. **R. Lee Kempner** has been elected president of Rio Grande Railway, succeeding **W. T. Eldridge**.

W. R. McMunn has been appointed superintendent of rolling stock of the Merchants Despatch, Inc., with headquarters at Rochester, New York.

G. W. Murphy has been appointed superintendent of the Bangor and Portland division of the Delaware, Lackawanna & Western Railroad, with headquarters at Bangor, Pa., succeeding **H. E. Griffith**.

John Daniels, road foreman of engines on the Oregon-Washington Railroad & Navigation Company, with headquarters at LeGrande, Ore., has been appointed general fuel supervisor, with headquarters at Portland, Ore., succeeding **A. W. Perley**.

L. F. Donald has been appointed assistant superintendent of the Chicago, Milwaukee & St. Paul Railway, with headquarters at Terre Haute, Ind., succeeding **T. P. Horton**, deceased.

R. M. Calkins has been appointed assistant to the receiver of the Chicago, Milwaukee & St. Paul Railway, with headquarters at Chicago, Ill.

A. B. Gloster has been made superintendent of the Louisville & Nashville Railroad, with headquarters at Middlesboro, Ky., succeeding **O. B. Hollingsworth**, deceased.

N. J. Boughton has been appointed engineer of tests of the Missouri, Kansas & Texas Railroad, with headquarters at Parsons, Kans., succeeding **C. L. Buckingham**, deceased.

C. F. Ault has been made car foreman of the Missouri Pacific Railroad, with headquarters at Omaha, Nebr., succeeding **P. L. Johnson**, resigned.

E. Shlottman has been appointed shop foreman of the Illinois Central Railroad, with headquarters at Natchez, Miss., succeeding **A. E. Martin**, transferred as general foreman to Cleveland, Miss.

Supply Trade Notes

Frank K. Metzger, manager of sales of the **Standard Steel Works**, Philadelphia, Pa., has been elected vice-president, to succeed **Richard Sanderson**, resigned. **R. Nevin Watt** succeeds **F. K. Metzger**.

B. W. Parsons has been appointed sales representative of the **American Locomotive Company**, with offices at 1010 Builders' Exchange, St. Paul, Minn. **Henry S. La Barge** has been appointed manager of railway and marine sales of the **Glidden Company**, Cleveland, Ohio.

The Railway Steel Spring Company closed its office in Louisville, Ky. The business of this district will hereafter be handled by **George B. Powell**, sales agent, Syndicate building, St. Louis, Mo. **W. E. Corrigan**, district sales manager of the American Locomotive Company, Rialto building, San Francisco, Calif., now represents the Railway Steel Spring Company, succeeding **Herbert G. Cook**. The business of the combined companies will be handled from Rialto building, San Francisco. **A. W. Sullivan**, sales agent of the **Railway Steel Spring Company**, at Pittsburgh, has moved his office to the Farmer Bank building, Pittsburgh, Pa.

The Link Belt Company, Chicago, has opened a sales and service branch at 152 Temple street, New Haven, Conn., in charge of **R. H. Hagner**.

The Pollack Steel Company, has opened a sales office at Detroit, in charge of **B. G. Lalman**, sales engineer, and **W. R. Klinkicht** metallurgist.

Charles E. Coles has been appointed representative of the **Acme Steel Company**, Chicago.

J. T. Stephenson, with office in the Munsey building, Washington, D. C., has been appointed railway sales representative in the territory of the **Warren Tool & Forge Company**, Warren, Ohio.

Archibald H. Ehle, general sales manager of the **Baldwin Locomotive Works**, has been elected vice-president in charge of domestic sales, to succeed **Grafton Greenough**, deceased. **Steward McNaughton**, sales manager of the central zone, with headquarters at Philadelphia, has been elected manager of domestic sales, to succeed Mr. Ehle.

John H. Rodger, vice-president in charge of the Chicago office of the **Safety Car Heating & Lighting Company**, has been promoted to vice-president in charge of railway sales, with headquarters at New York City. **George H. Scott**, representative at Chicago, has been appointed to succeed **John H. Rodger**.

W. P. Steele, accessory sales manager of the **American Locomotive Company**, has resigned.

Carl F. Purscher, formerly in the stores department of the Boston & Maine Railroad, has been appointed representative of the signal department of the **Railroad Supply Company**, with headquarters at Boston, Mass.

Arthur C. Dunne, sales engineer of the **Chicago Railway Signal & Supply Company**, has been promoted to resident manager, with headquarters in the People's Gas building, Chicago, Ill.

Norman C. Naylor has been appointed district sales manager of both the **American Locomotive Company** and the **Railway Steel Spring Company**, with headquarters at McCormick building, Chicago, Ill.

A. N. Martin, formerly in charge of the purchasing department of the **Pyle National Company**, with headquarters at Chicago, has been elected vice-president, with headquarters at New York.

W. R. Foster, formerly sales engineer of the **Bridgeport Brass Company**, has entered the employ of the **American Brown Boveri Electric Corporation**, with headquarters at New York.

The American Steel Foundries Company has purchased the **Verona Steel Casting Company**, Verona, Pa.

Warren Corning has become president of the **Chicago Tube & Iron Company**, following the consolidation with **Warren Corning & Company**. **Fred Gardner** becomes vice-president and general manager.

A. T. Herr has been appointed sales representative of the **American Locomotive Company**, at Denver, Colo., and **I. W. Harty** has been appointed sales representative at Detroit, Mich., with offices in the General Motor Corporation building.

Orrin H. Baker, of the sales department of the **Illinois Steel Company**, has been promoted to assistant general manager of sales in charge of the rail bureau, to succeed **P. W. O'Brien**, deceased.

Burton L. Delack, assistant manager of the Erie works of the **General Electric Company**, has been appointed assistant manager of the Schenectady, New York, works. **John St. Lawrence** succeeds Mr. Delack.

The National Railway Signal Company, a new corporation, has purchased the **United Electric Apparatus Company**, manufacturers of the Ziegler line of relays and electric block signal appliances.

G. G. Jones has been made sales engineer of the **American Locomotive Company**, with headquarters at Chicago, Ill.

Henry Donovan has resigned as general manager of the plants of the **General American Car Company**.

W. H. Winterowd has been chosen vice-president of the **Lima Locomotive Works**, with headquarters at New York City.

Obituary

Thomas Neilson Jarvis, formerly vice-president of the Lehigh Valley Railroad, died on November 14, at the age of 72. Mr. Neilson was born on May 22, 1854, at Stratford, Ont., Canada, and entered railway service September, 1872, as clerk in the freight office of the Grand Trunk Railroad and was later transferred in the same position to Black Rock, New York. He later became voucher clerk in the general office of the International Line at Buffalo, New York. From 1880 until 1883 he was accountant for the Commercial Express Line, and from the latter date until 1898 he was manager of the Traders' Dispatch Fast Freight Line. He entered the service of the Lehigh Valley Railroad as general eastern freight agent, with headquarters at New York City and later became assistant freight agent. In 1903 he was appointed general freight agent and then freight traffic manager. In 1906 he became vice-resident, which position he held until his retirement in 1918.

William Larimer Jones, president of the Jones & Laughlin Steel Corporation, died on November 25 at his home in Pittsburgh. He graduated from Princeton University in 1887 with the degree of bachelor of science and from that time devoted his time to the steel manufacturing industry. He was assistant to his father Thomas M. Jones, general manager of the company, and upon the latter's death succeeded him as general manager. In 1906 he was elected vice-president of the company, and upon the latter's death succeeded him as general Laughlin Steel Corporation was made its president, succeeding B. F. Jones, Jr., who became chairman of the board of directors.

John Rainey McGinely former assistant of the late George Westinghouse, with whom he organized the Westinghouse Electric & Manufacturing Company died on November 20 in New York City, at the age of 75. Mr. McGinely served with the Philadelphia Company of Pittsburgh as vice-president and general manager for many years. He was a director of the Chicago Pneumatic Tool Company director of the Duff Manufacturing Company, chairman of the board of the Pittsburgh Screw & Bolt Company, and a director of Dwight P. Robinson & Company, Inc.

J. M. Snodgrass, professor of railway mechanical engineering department of railway engineering, University of Illinois, and a member of the the A. S. M. E., died on December 4, following an operation for cancer. Mr. Snodgrass graduated from the University of Illinois in 1902 with a degree of B. S. in mechanical engineering. From 1902 to 1906 he was instructor in mechanical engineering and in railway engineering at the university. He was then employed by the American Locomotive Company, returning in 1908 to the University as associate and assistant professor in the department of mechanical engineering and special investigator in the engineering station. In 1913 he became assistant professor and then later professor of railway mechanical engineering in the railway department of engineering.

George Hull Porter, railway sales manager of the Graybar Electric Company, with headquarters at Chicago, died on December 7, of apoplexy. He was born on July 30, 1883, at Danbury, Conn., and received his education at the Mount Pleasant Military Academy. He became a member of the Western Electric Company in 1908 as a steam railway salesman, with headquarters at Chicago. Later he was promoted to western manager of the railway sales department, which position he held until 1918, serving as a private on the staff of the quartermaster and later a captain. He returned to the Western Electric Company and was appointed railway sales manager to direct the company's railway business for the entire country. In December of last year the Graybar Electric Company was organized to take over the electric supply business of the Western Electric Company. Mr. Porter remained in the same capacity with the Graybar Electric Company until his recent death.

New Publications

Books, Bulletins, Catalogues, Etc.

Wrought Steel Wheels and Forged Steel Axles. The Carnegie Steel Company, Pittsburgh, Pa., has just issued a book of forged steel wheels, piston blanks and axles, as made by them. The book contains drawings, specifications and data on the products described, which include lightweight wrought steel wheels which were the subject of their last booklet, make this volume a complete hand book on circular forgings. Copies of the book may be obtained from the company.

The Railway and Locomotive Historical Society, Brookline, Mass., has issued its No. 12 Bulletin, containing notes on the recent anniversary celebrations of the New York, New Haven & Hartford Railroad and the Missouri Pacific Railroad, and the early days of the Iron Horse in North Carolina, and other data on locomotive history. The article by Inglis Stuart gives details of the history of the New York, New Haven & Hartford Railroad.

Sludge Remover. The Bird Archer Company, New York, has issued a booklet on the use of the blow-off cocks and sludge removers for locomotive boilers. The sludge remover is extensively used on the Canadian National Railways. It consists of a blow-off cock and internal pipes arranged for the removal of precipitated sludge from the boiler barrel and fire box water legs. Copies of the booklet can be obtained from the company.

Tests of the Fatigue Strength of Cast Steel. By Herbert F. Moore. This bulletin will be issued by the Engineering Experiment Station of the University of Illinois. For your convenience a brief review of the bulletin is given.

The widespread and growing use of steel castings for stress-carrying members in machines and structures, especially in railway rolling stock, has called attention to the lack of available data on the fatigue strength of this material, that is, the ability of steel castings to resist repeated stress without being fractured. Owing to the need of such data the Engineering Experiment Station of the University of Illinois in cooperation with the American Steel Foundries undertook to make a series of fatigue tests on cast steel.

This investigation, carried out in the laboratories of the Investigation of the Fatigue of Metals, included a study of the strength of cast steel as a material. Tests were made of specimens cast as lugs on the under side of a fairly heavy steel casting. Two kinds of steel were used, one having a high manganese content and the other being fairly representative of ordinary steel castings. Two metallographic studies were made of the effect of heat treatment on the crystalline structure of the steel. No heat treatments were used which involved water quenching or oil quenching. The maximum temperature and the time of "soaking" at maximum temperature were the variables studied.

Bulletin No. 156 of the Engineering Experiment Station of the University of Illinois contains a discussion of the methods used in testing and gives the data of the fatigue tests as well as a summary of the results obtained from this investigation. Among the conclusions drawn, as stated in the bulletin, one of great importance is that for the cast steels tested the ratio of endurance limit to ultimate tensile strength averages 0.42, which is slightly less than the average value for ordinary rolled steel.

Simplex Coaling Stations. The Roberts & Schaefer Company, Chicago, Ill., has recently issued an illustrated catalog on its latest development in locomotive coaling plants, covering such features as the Simplex roller skips, loaders, coaling gates and aprons, and automatic electric hoists. The catalog shows cylindrical storage tanks of various capacities as arranged to serve coal to locomotives on from one to six tracks. Copies of catalog may be obtained from the company.

The Internal Combustion Engine, by Harry R. Ricardo, B. A., A. M. & C. E., M. & A. E. Published by D. Van Nostrand Company, New York, N. Y. 2 Vols., 6¾ x 10. Bound in Cloth. Price $9.00 ea.

They are books which contain a comprehensive treatise on the principles of design of the modern internal combustion engine. The various makes of engines are described and illustrated and their efficiency for special uses critically discussed. The volumes are both fully illustrated and contain many tables of data of great value to the designer. Volume I. contains chapters covering: Thermal Efficiency; Principal sources of loss of efficiency; Condition under reduced loads; The Diesel Engine; Two-cycle Diesel engine; Determination of the mechanical efficiency; Piston Friction; Examples of large two-cycle gas engines; Small two-cycle engines; Low efficiency two-stroke engines, and Volume II. contains chapters on Volatile liquid fuel for internal combustion engines: Detonation; Distribution of heat in a high speed four-cycle engine; Lubrication and bearing wear; Mechanical design; Mechanical details; Valves and Valve gear; Piston design; Engines for road vehicles; Aero-engines; High speed duty engines for tanks, etc.

Clearing the Way for the Comforts of Life. This is the title of a sixteen page pamphlet issued by the Ingersoll Rand Company, 11 Broadway, New York, N. Y. A brief and attractively illustrated history of land and early water transport in this country. It describes the debt America's prosperity owes to the builders and to the operators of the country's railroads. The public are unaware of the indebtedness. Copies of the pamphlet can be had on request by addressing the company as above.